TOWARDS SCIENTIFIC AND TECHNOLOGICAL LITERACY FOR ALL IN AFRICA

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Preface

The main objective of the World Conference on Education for All in Jomtien, Thailand from (5 - 9 March 1990) was to meet the basic learning needs of all. This is an ambitious objective in as much as the field of basic learning needs is vast. Its elements are also manifold, constantly changing . The approach to be adopted is therefore complex whatever the area considered .

This publication tries mainly to throw some light on the concept of scientific and technological education for all as perceived in Africa from the colonial period to today. This issue is crucial for the future of the continent, since all previsions indicate that science and technology will play a major role in the 21st century. In order for Africa to be in tune with the rest of the world and for its own survival, it is imperative that our continent strengthens its mechanisms for knowledge and scientific and technological processes appropriately so that each member of its community be equiped with the basic skills necessary to understand, explore and exploit judiciously its physical environment and resources.

Articles in the first section of the book try to lay the foundations of a scientific and technological education and culture of all in Africa in line with the project 2000+. The project 2000+ is an international project launched by UNESCO which aims at making scientific and technological culture a reality for all from the beginning of the 21st century. It falls right within the framework of the objectives adopted by the World Conference on Education for All and the United Nations Conference on Environment and Development.

It is in this perspective that Prof. P. OKEBUKOLA in his article aims at clarifying the concept of scientific and technological education for all in Africa, identifies its objectives and its "key elements", makes a proposal for a programme and suggests strategies for its implementation.

Prof. S. T. BAJAH's contribution opens up on a series of three questions which cover all the scope of the concept of scientific and technological education for all in Africa. He concludes by suggesting concrete modalities for scientific and technological education programmes for the various target-groups.

Mrs NGANANU advocates a science and technology " compromise programme " which favours the emergence of scientific vocations among the youth and the development of skills for real life among the pupils who leave school early.

Prof. Magnus COLE, an African specialist of indigenous technologies, considers that scientific and technological education should pay attention to local and regional development needs. It should also take into account scientific and technological heritage of societies in order to adapt it in an appropriate manner to the modern context.

Prof. Magatte THIAM adopts the same approach as Prof. OKEBUKOLA as regards the perception of the nature of science and technology as well as issues related to the relevance of contexts and target-groups.

All these " future-oriented thoughts " find elements of application in the studies and experiences described in the second section of the book. These elements of application are choices made by the project " popularization of science and technology ", the African component of the project 2000+. This component intends to lay emphasis, on children and girls.

According to specialists, scientific and technological education should start in the cradle; in any case it should start at early age. Nevertheless, it should be admitted that Africa suffers from great shortages as regards scientific and technological publications for the youth. Investigations by Prof. OKEBUKOLA concerning supplementary science and technology reading materials show the scope and seriousness of this shortage. His study is an invitation to indigenous writers to give more attention to this type of production.

Due to multiple prejudices, the participation of women and girls in scientific and technological activities still remains low in Africa. Scientific and technological clinics launched in Bostwana and Ghana are response elements for promoting the access of women and girls to science and technology studies. There are other similar programmes under execution in Africa in the area of formal and non-formal education in Africa.

This book is only the beginning of a debate which concerns all educators particularly science teachers. This debate is inevitable if science and technology is to be accessible by the beginning of the 21st century to all social classes in African countries.

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GENERAL CONSIDERATIONS

Chapter One

DEVELOPING AND IMPLEMENTING A SCIENCE AND TECHNOLOGY EDUCATION PROGRAMME FOR ALL AFRICANS

Peter *OKEBUKOLA**

INTRODUCTION

The main aims of this paper are to identify and discuss major issues relating to science and technology education for all in Africa. Priding itself as the 'cradle of human civilization', Africa lays claim to being where some of the earliest technologies were initiated and developed. Incidentally, this early lead is lost in history. Africa now rates as one of the backward continents in science and technology enterprises (Ikeobi, 1992). Consequently, as we approach the 21st Century, the issue of science and technology education for all in Africa is eminently worthy of being addressed.

Following a series of observations in the early 1830s, Charles DARWIN, a British naturalist, came up with the theory dubbed 'survival of the fittest'. This Darwinian position which is true today as it was on the Galapagos Islands in 1833, reminds us that only elements in a community that are able to adjust to changing conditions in the environment will be naturally selected for the next generation. The inference here is that only those who have the knowledge, skills and attitudes that are attuned to the world of the 21st Century will survive.

It is envisioned that the totality of the environment of the 21st Century – social, political, economic, climatic and cultural, will be different from what we have today. Survival of Africans in that world of the future will be dependent strongly on our ability to better understand and adapt to changes in our physical and human environments.

It is important, as Ellyard (1989) suggests, that we should have visions and be able to create pathways towards achieving our targets for

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the future. This paper is hinged on a visionary model of science and technology education for all in Africa and the creation of pathways towards achieving anticipated targets. The objectives of the paper are to:

(i) clarify the concept of science and technology education for all ;
(ii) identify the objectives of science and technology education for all;
(iii) suggest the content of programmes of science and technology education for all in Africa ; and
(iv) identify strategies for promoting science and technology at all levels of formal education, as well as out-of-school.

CLARIFICATION OF THE CONCEPT OF SCIENCE AND TECHNOLOGY EDUCATION FOR ALL

Science and technology education for all is a concept that is subsumed within the more fundamental and broader issue of '*Education for all*'. This broader issue which has been the subject of two major declarations, is primarily aimed at providing the enabling environment for the education of all the citizens of the world. The first of these, the Universal Declaration of Human Rights accented to by member countries of the United Nations asserts that '.....everyone has a right to education'. In March 1990, the World Declaraton on Education for All was proclaimed. Article 1 of this Declaration states that 'Every person, child, youth and adult- shall be able to benefit from educational opportunities designed to meet their basic learning needs'. Together, these declarations project the belief in the power of education for improving the lot of mankind.

In clarifyng the concept of science and technology education for all, certain operational definitions would need to be made. For instance, such questions as : *What is science? What is science education? What is technology? What is technology education? Who does the 'All' include?* are basic to an understanding of the concept of science and technology education for all. The answers to the questions also provide the operational definitions for the concepts of interest.

What is Science?

For the purpose of this paper, science is taken to be the human activity whose processes are directed at an understanding of the natural world and whose products are aimed at making the world a better place for man (Bajah & Okebukola, 1984). Science is thus, a way of knowing the world based on particular methods of inquiry. Its practice according to the Australian National Science Statement, includes experimenting, developing and testing theories, creating new theories and abandoning others, evaluating and applying information, making decisions and solving problems.

In Bajah's (1992) view, science is an adventure of the human mind that is stimulated largely by curiosity. Science, according to him is not technology, gadgetry, some mysterious cult, a great mechanical monster, 'white man's lies' or magic. Several science educators in Africa including Apea (1992) Anamuah-mensah (1989) Ogunniyi (1988) Jegede (1992) Jegede and Okebukola 1989) and Ajeyalemi (1986) are agreed that science is a dynamic human endeavour which leads us to better understand the world.

What is science education?

Science education is taken to be the provision of learning experiences aimed at the development of knowledge, skills and attitudes in the processes and products of science. In his inaugural address, Balogun (1988) considers science education to be the teaching and learning of science in formal, informal and non-formal settings.

What is technology?

Technology is a process involving the application of scientific knowledge and also a body of knowledge that is used in fashioning human inventions (products) for the well-being of man. Technology is a source of cultural transformation (Shymansky & Kyle, 1992). It is a social process achieving social ends, not an end in itself.

What is technology education?

Technology education is taken in this paper to mean the provision of learning experiences that will lead to the development of technological process skills and the acquisition of knowledge in the area of human inventions and innovation.

Who does the 'All' include?

All children, youth and adults irrespective of gender, creed, political affiliation or other peculiarities are included in this provision. Aside from this statement of universality is that of equity. Article 3 of the World Declaration on Education for All emphasizes gender equity, catering for disabled persons and providing for underserved groups – the poor ; street children and working children, rural and remote populations ; nomads and migrant workers ; indigenous peoples ; ethnic, racial, and linguistic minorities ; refugees ; those displaced by war ; and people under occupation. A major frame of reference in this paper is the formal education sector. The 'All' in this context includes those individuals in the schooling community from primary to tertiary level.

SCIENCE AND TECHNOLOGY EDUCATION IN THE CONTEXT OF EDUCATION FOR ALL

There are two models of looking at the concept of science and technology education for all. One of these, the 'solo' model considers science and technology worthy of singular pursuit in a mass literacy programme. All elements and mechanisms of the programme are solely directed towards ensuring scientific and technological literacy. The other, the 'Integrated model' embeds science and technology education within a framework of the education for all pursuit. Science and technology education is seen as a 'slice of the education for all cake' -a key component of the educational provisions of a mass literacy programme. This is the model adopted in this paper.

Fig. 1 depicts this model and shows the expectations of some scientists and technologists recently surveyed, of the proportion that scientific and technological literacy should take within a programme on education for all in Africa. Projections are given in quarterly segments of the 21st Century.

Project 2000 + is also developed along the lines of the integrated model. The project is a joint initiative of UNESCO and the International Council of Associations for Science Education (ICASE). The primary goal of the project is to promote and to guide the implementation of the scientific and technological dimension of basic education in the context of education for all. The project seeks to :

(a) identify ways of promoting the development of scientific and technological literacy for all ;
(b) put forward educational programmes (both formal and non-formal) in such a way as to empower all to satisfy their basic need and be productive in an increasingly technological society ;

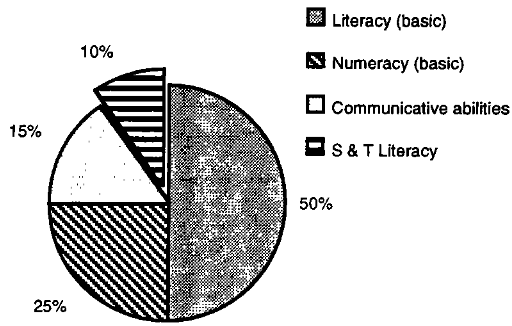

Fig 1a: S & T Literacy within the framework of education for all (2 000 AD).

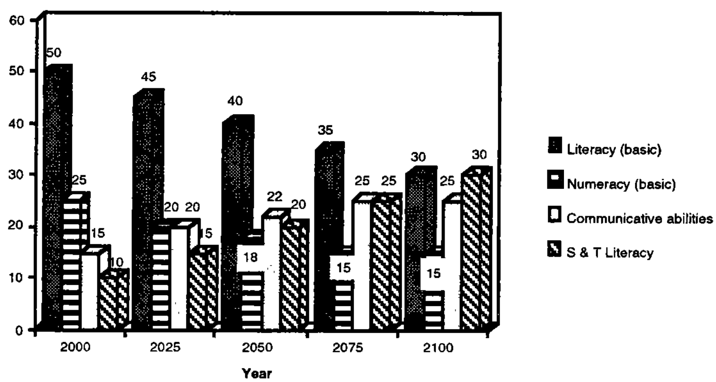

Fig 1b: S & T Literacy within the framework of education for all in Africa.

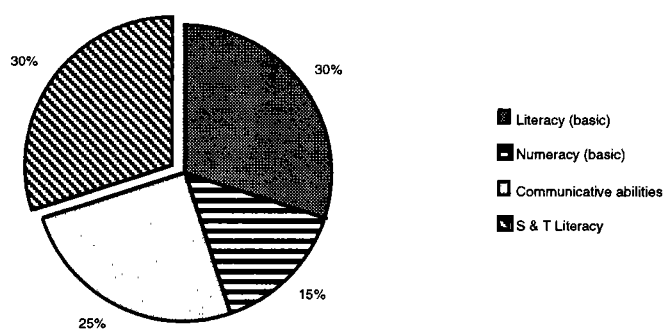

Fig 1c: S & T Literacy within the framework of education for all in Africa (2 099 AD).

(c) provide guidelines for the continuous professional development of science and technology educators and leaders ;

(d) encourage the formation of national task forces involving personnel from Government, Inter-Governmental Organizations (IGOs), and from Non-Governmental Organizations (IGOs) such as Associations for Science Education – to initiate programmes for greater scientific and technological literacy ;

(e) support the development of a wide range of projects that aim to improve quality of life and productivity in society and lead to promoting solidarity and cooperation in achieving scientific and technological literacy for all ; and

(f) support the evaluation of existing and projected programmes to ensure that scientific and technological literacy goals are being met.

NEED FOR A PROGRAMME ON SCIENCE AND TECHNOLOGY EDUCATION FOR ALL IN AFRICA

There is a plethora of reasons why a great deal of efforts should be invested on science and technology education for all in Africa. For ease of description, a number of the major reasons have been aggregated under three headings – cultural, economic and social.

Cultural reasons

Indigenous technology in Africa was a marvel of the ancient past. The technology in agricultural practices, building, and textile production showed great promise, but was hardly improved. Several factors are implicated in the slow growth. A major one is the low level of literacy, especially scientific and technological literacy, in the region. If the literacy level had observed a steady and appreciable growth, technology in Africa would have been the marvel of the 20th Century and a leader in the 21st. There is an urgent need to improve, through a science and technology education for all programme, the scientific and technological literacy level of Africans to promote Africa from the back seat to a leadership position in science and technology, through the radical development of its indigenous technology.

Another culture-related reason is the need to free the minds of Africans of superstitious beliefs and taboos which have been shown to inhibit different facets of development in the region. The replicability, testability and experimentation which characterise science, are important skills which basic scientific training will give to the populace. These skills will facilitate the transformation of the superstition and taboo-ridden world view of the people. The people can be availed the opportunity of these skills through a scientific and technological literacy programme.

Sciencific knowledge, judgement and imagination should become part of the socio-cultural heritage of every African. We look to science not only to increase man's control over his environment but to inform and enrich the immensely varied patterns of man's encounter with man.

Economic reasons

Africa consistently recorded the lowest Gross Domestic Product per capita of all the regions of the world between 1980 and 1986. Sub-saharan Africa stagnated and now seems to be undergoing a macro-economic decline. World Bank projections for 1995 put the GDP per capita for Sub-saharan Africa at 0.7, the lowest in the world. Rising debt burdens and falling prices of commodities are reducing the prospects of fiscal revenue. Improved industrialisation, production and export are key variables that can turn the situation around. Our fitness to survive in a fierce international competition undoubtedly depends on industrial production, inventiveness, trade, and exports which have science and technology as the core. Science and technology literacy for the citizens could, therefore, translate into practices which will lead to improvement in Africa's productive capacity.

There is an increasingly wide range of jobs for which training in science and technology is highly useful if not essential. Science and technology is also infiltrating into the practice of all professions. Consequently, if the populace has the benefit of science and technology education, employment opportunities are likely to be more available. People are also likely to be more productive and effective at work, with an ultimate bolstering effect on the economy.

Social reasons

Africa, like the rest of the world, now lives in a world that is shaped by science and technology. Consequently, we shall live better and more happily if we know a little bit more about science and technology enterprise.

Technology is altering our material environment almost out of recognition. It is not enough to say that scientists and technologists should get on with their works while the rest of us enjoy their products without understanding. We should use and choose their inventions better if we know at least something about how they operate.

Science and technology is also shaping our world especially through technology of communications – telephone, radio, aeroplanes, satellites turning the world into a global village. Africans shall be respected members of this global village if we are able to contribute to the development of science and technology. In addition, science and technology – related problems at the national, regional and global levels can be better tackled if more of us understand science and technology.

Population growth rate, infant mortality and health practices in Africa have, in recent times, been the subject of not-too favourable comments by the World Bank, Unicef and WHO. The High illiteracy level in Africa is taken to be a major factor accountable for the unacceptable state of affairs. With a more science and technology literate citizenry, a better performance for Africa in population and health-related issues, may be ensured.

Other considerations

The benefit of a science and technology education programme can also be considered from the perspective of the individual, the nation and at level of the continent. Fig.2 provides a summary of this perspective.

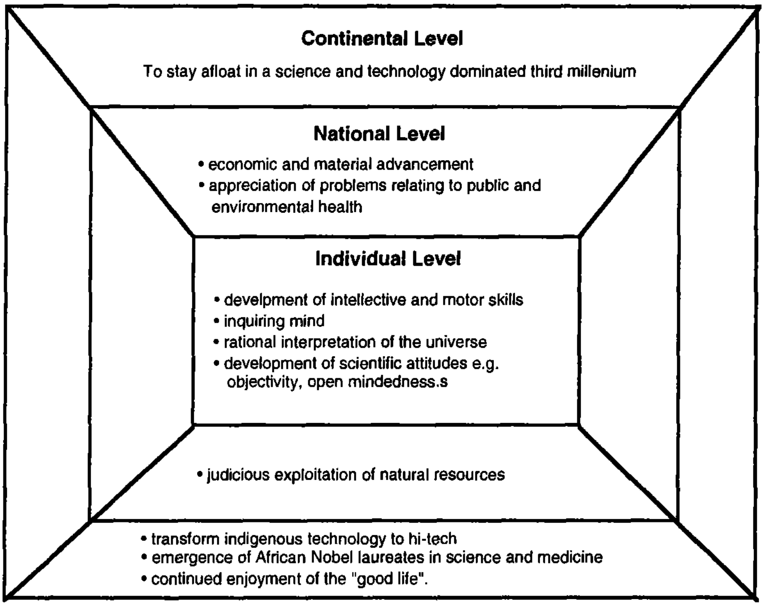

Fig. 2. : Benefits of a science education programme at the individual, national and continental levels in Africa.

Perspectives from Project 2000+

Scientific and technological literacy, according to a Project 2000+ document, are essential for all to meet the challenge of :

(i) the increasing impact of science and technology on people's lives, individually and in relation to society, as well as to their careers and quality of life ;

(ii) the need for scientists, politicians and other key personnel to be scientifically and technologically literate as a basis for decision making, and for citizens to be able to participate meaningfully in science-related political issues ;

(iii) the need for people to be functional in an increasingly technological environment ; 'operacy' in relation to machines ; appropriate societal behaviour for the benefit of the individual and society as a whole ; and

(iv) the need for a flexible work force which can be more effective if scientifically and technologically literate.

THE GOAL AND OBJECTIVES OF SCIENCE AND TECHNOLOGY EDUCATION FOR ALL IN AFRICA

The Goal

To avail all individuals in Africa, the opportunity to acquire knowledge, skills and attitudes that will lead them, to make effective use of the processes of science and technology in their work and personal lives, wether or not they are engaged in scientific and technological occupations, and to deal with change that accompanies developments in the science and technology.

General objectives

The following are taken to be the general objectives of a science and technology education for all in Africa :

(a) To equip Africans, irrespective of present and future career orientations, with basic knowledge, skills and attitudes in science and technology, and enhance potentials for improving the quality of life in the region.

The quality of life, in its broadest sense, is inextricably linked to a basic understanding of the processes and products of science and technology. Issues relating to shelter, clothing, food and agriculture, health and safety are basically issues of science and technology. Basic education in science and technology should, therefore, be part of a programme for improving the quality of life in Africa – the much talked about target of governments in the region.

(b) To provide a foundation for further education and training in science and technology for those who will ultimately go into careers in science and technology.

A basic scientific and technological literacy programme for all will form the basis on which to mount further courses. This arrangement, in turn, leads to specialization in science and technology. There is also the added advantage of the basic literacy programme stimulating many more of its beneficiaries into taking up careers in science and technology.

(c) To facilitate the social, economic and political development in the region.

The relationship between science and technology development and developments in the social, economic and political sectors is well established. Evidence abounds to show that countries which have made tremendous progress in science and technology have well-developed social, economic and political systems. It is anticipated that through the rapid development of science and technology, with science and technology education for all as the vehicle, Africa will experience noteworthy advances in social, economic and political enterprises.

(d) To increase the pool (in quality and quantity) of scientists and technologists.

It is evident that Africa needs more scientific and technological manpower. The 1990 Digest of Statistics in Science and Technology shows that Africa contributes the least to the world's pool of scientists and those involved in technology-related occupations. Unfortunately, reports from several African countries (Walberg, 1990) show that young people are avoiding science classes at a time when world dependence on science and technology capability is increasing. It is anticipated that a programme on science and technology education for all in Africa will increase the number of 'converts' for science and technology, and ultimately lead to an increase in the quality and quantity of those who are engaged in science and technology occupations in the region.

Specific Objectives

A programme of basic scientific and technological education in Africa should enable those exposed to it to :

(a) recognise problems in nature especially those that are indigenous to Africa ;

(b) be willing to approach a problem and make an effort to solve it ;

(c) observe occurrences in nature with all the senses – sight, hearing, smell, taste and touch ;

(d) record observations accurately with no bias, recognising that science is self-correcting ; false claims today will be revealed by later studies tomorrow ;

(e) reason about, discuss and make simple deductions from observations ;

(f) acquire adequate vocabulary to communicate observations and ideas (either in the local language or in a form that can be comprehended by others) ;

(g) carry out measurements of weight, length, volume, time and temperature as accurately as possible ;

(h) handle simple tools and equipment especially those that can be used for ;
   (i) carry out scientific investigations ; and
   (ii) farming and other forms of indigenous technology;
(i) improve the design and construction of existing tools ;
(j) design experiments to test wise guesses about events happening in the natural environment ;
(k) learn simple facts, principles and concepts related to such areas as food production, processing and storage, pollution, desert and ocean encroachment, energy (including solar energy), housing, birth practices, health care delivery, communication, deforestation, drug use and abuse, and the medicinal and food contents of plants;
(l) develop attitudes such as objectivity, open-mindedness, respect for evidence, willingness to change opinion in the face of incoming evidence, scepticism and critical mindedness ;
(m) develop a spirit of cooperation among members of the society resulting in the pooling of resources that will facilitate an understanding of the world in which they live;
(n) identify the limitations of science in terms of what it can do and what it cannot do ;
(o) identify the positive and negative aspects of the use of science and technology by man.
(p) show concern for and respond to the consequencies of human interactions with the environment :
(q) take decisions from a scientifically and technologically informed position ; and
(r) develop and refine their views of the world, explain their experiences and answer questions about themselves and the environment.

CRITERIA FOR SELECTION OF CONTENT

Objectives of the programme

Curriculum theorists regard the objectives of a programme as the major criterion for content selection. It is the objectives that guide the development and implementation of the curriculum process. In selecting content for a programme on science and technology education for all, one needs to be guided by what have been specified as the targets of the programme. The content that will ensure that we get to these targets or objectives will hence be carefully selected and aligned with these targets or objectives.

Nature of the beneficiaries

The interest, motivation, abilities and other individual or group characteristics of the beneficiairies of the programme is yet another important filter for selecting curriculum content. For a science and technology education programme for all, careful attention will need to be given to the individual and group characteristics of children, youths and adults that will be catered for by such a programme.

Relevance

The concept of relevance is central in curriculum planning and development. This centrality accounts for the numerous perspectives on the meaning of concept. For a programme on science and technology education for all, relevance should relate to the needs of the individual, the needs of the society and the aspirations of Africa in the science and technology enterprise.

Practicability

Contents to be selected should be those that the present and anticipated future economic positions of the adopting countries can support. It is clearly unwise to include contents for an'ideal model' whose implementation assumes that everything is or would be in place. The reality is that things are 'far from equal'. It is expedient, therefore, to select only those contents in science and technology that social, political and cultural realities can support.

Balance

The need to reflect all the focal areas of interest should guide content selection. This ensures balance especially if breadth and depth of content are well taken care of.

Interdisciplinarity

The wish to be science and technology literate is not a wish for specialisation by all citizens. A broad-based presentation of science and technology subject matter would, therefore, appear to be what is needed. Interdisciplinary and integrated approach to curriculum development in science and technology should guide the effort in content selection.

Content selection should stress the fundamental unity of the sciences as we have in the various integrated science programmes.

Man-environment focus

The perception of the utility value of a science and technology education programme is, to a large extent, the perception of how its contents relate to the everyday experiences of the learner. A better understanding of the immediate environment gives those exposed to a science and technology education for all programme, 'a surer grip on life'. This is well achieved by content which focus on the relationships and interactions between man and his environment.

PROPOSED CONTENT

It is proposed that the contents of a science and technology education for all programme should be anchored on four themes. The scientists at work ; my body at work ; technology in the service of man ; and conserving natural resources. Using these themes as guide, suggestions are made with respect to content in Fig.4 and Tables 1 and 2.

BASIC THEMES

The scientist at work

- Systematic approach to solving everyday problems from identification to problem solution
- Using scientific process skills in solving everyday problems: observing, measuring, experimenting, hypothesising, inferring, communicating, classifying
- Application of scientific attitudes in problem solving: honesty, objecting, perseverance, respect for evidence etc.

My body at work

- Parts of the human body (external and internal)
- Nutrition, respiration, movement, growth excretion, control and coordination and reproductive functions of the human body
- The body in health and disease

Technology in the service of man

- Basic principles guiding the operations of common household appliances (e.g radio and electric iron) and other products of science and technology in common use e.g cars
- First aid in fault diagnosis and repairs of domestic appliances
- Improving indigenous technology in use especially in agriculture and building activities

Conserving and preserving our natural resources

- Global issues: Population control, greenhouse effect and ozone layer depletion
- Need and techniques for conserving our natural resources especially soil, water wildlife, forests and minerals
- Public health: refuse disposal

Fig. 3 : SCIENCE AND TECHNOLOGY EDUCATION FOR ALL PROGRAMME IN AFRICA

Table 1

CORE TOPICS OF THE BASIC SCIENCE AND TECHNOLOGY PROGRAMME

Topic	Objectives	Content
What science and technology are about	• Give a simple definition of science and technology • Identify problems in nature • List various steps which scientists and technologists use in solving a problem	• Meaning of science and technology • Nature of the method used by scientists and technologists to solve problems in nature
Exploring the environment	• Observe and identify living things • Use the senses in exploring the environment	• Identification of different components of the environment • Use of the senses
Activities of living things (with special reference to man	• Identify the characteristics of living things • Describe the basic processes involved in nutrition, movement, respiration, excretion, growth, response to stimuli and reproduction in plants and animals, especially man	• Characteristics of living things • How and why plants and animals especialy man move, feed, respire, excrete, grow, respond to stimuli and reproduce.
Matter	• Name the different states of matter • Give examples of solids, liquids and gases • State the properties of the different states of matter • Carry out activities showing how one state can change to the other	• What matter is • States for matter • Properties of solids, liquids and gases • Change of state

Measurement	• State the need for standard measurement • Name the units for the measurement of length, volume, weight/mass, time, temperature • Use appropriate instruments to measure length, volume, weight/mass, time, and temperature	• Need for standard measurement • Units of linear, volume, time, weight/mass and measurements • Instruments used for measurement • Measuring length volume weight/mass, time and temperature
Energy	• Define energy • List sources of energy • State different forms of energy • State the major features of different forms of energy • Describe how man uses forms of energy	• What is energy • Sources of energy • Forms of energy and their interconversion • How man uses mechanical, heat, light, chemical, electrical, sound, magnetic, and atomic energy
Air	• List the constituents of air • Carry out activities to find out the properties of air • Describe the use of air by man	• Constituents of air • Properties of air • Use of air by man
Water	• Identify sources of water • Carry out activities on the methods of purifying water • State the uses of water in the homes, farms, industries, etc • Describe how water can be conserved	• Sources of water • Purification of water • Uses of water
Diseases	• Identification of common diseases and their symptoms • Identification and life histories of disease vectors e.g mosquito, housefly, tse-tse fly,blackfly • State how diseases can be prevented	• Common diseases and their symptoms • Disease vectors • Prevention of diseases
Elements mixtures and compounds	• Explain what an element is • Describe mixtures and compounds with examples • Carry out activities to separate mixtures	• What elements, mixtures and coumpounds are • Methods of separating mixtures

Atoms and molecules	• Describe very simply the structure of the atom • Give examples of atoms and molecules	• The structure of the atom • Examples of atoms and molecules
Metals and non-metals	• Distinguish between metals and non-metals • Describe simple processes for extracting some metals that are found in the local environment • List the uses of common metals and non-metals • Carry out activities on the prevention of rusting	• Differences between metallic and non-metallic elements • Extraction of common metals e.g iron • Uses of common metals and non-metals • Rusting of iron and how to prevent it
Chemical symbols and formulae	• Identify the chemical symbols of some elements • Write the chemical symbols of some compounds	• Chemical symbols of common elements e.g oxygen carbon and iron • Chemical symbols of common coumpounds eg NaCl, CO2
Weather	• Explain the term "Weather" • Use instruments to measure rainfall, humidity, temperature, wind speed and pressure • Describe the effect of the weather on man and agriculture • Predict the weather	• What is weather? • Measurement of rainfall, humidity, temperature, wind speed and pressure • Effect of weather on agriculture and man • Predicting the weather
Our earth and sky	• Describe the earth, the sun and the solar • system • State the cause of day and night, and the seasons • Observe the moon, shadow, and the constellation • Carry out activities to show eclipses	• Day and night • Eclipse of the sun and moon

Table 2

CONTENT OF THE ENRICHMENT PROGRAMME ON KEY ISSUES

Topic	Objectives	Content
Food production	• Acquisition and use of skills for increased food production	• Soil fertility and management • Propagation of crops • Management of farm animals • Types of farming systems • Cultural practices; mechanised agriculture and use of fertilisers to boost food production
Food processing	• Acquisition and use of skills for processing, storing and preserving food	• Methods of processing and preserving food e.g; salting, drying, canning, refrigeration, pasteurisation • Importance of food storage • Methods of storing food; merits and demerits of each method
Desert and Ocean encroachment	• Identify causes of desert and ocean encroachment. Carry out activities aimed at arresting desert and ocean encroachment	• Causes of desert and ocean encroachment • Arresting desert and ocean encroachment
Drug abuse	• Classify drugs • Describe the effects of drug abuse on man • Manage drug patients	• Simple classification of drugs and use(s) of each class of drugs • Drug abuse and its effects • Avoiding drug abuse • Management of patients
Pollution	• Identify the causes of air, water, sound and soil • Carry out activities aimed at controlling/preventing pollution	• What pollution is : types • Effects of pollution : acid rain, etc. • Control of air, water, soil and sound pollution

Deforestation	• State the uses of forest trees to man • Describe deforestation • State the effects of deforestation • Identify the control of deforestation	• Uses of forest trees • Concept of deforestation • Effects and control of deforestation
Population growth	• Describe the growth of human population • State the effect of over-population on man • Identify methods of control of excessive increase in human population	• Nature of the growth of human population • Effects of over-population • Control of human population
Solar energy Medicinal and food plants	• Use solar energy as source of power for domestic, agricultural and industrial appliances • Identification and use of local plants for their medicinal and food contents	• Uses of solar energy • Identification of common plants with medicinal properties. Extraction and use of medicinal ingredients in such plants
Recent advances	• Familarity with recent advances in science in such areas as biotechnology implications for the African technology	• Advances in science in biotechnology

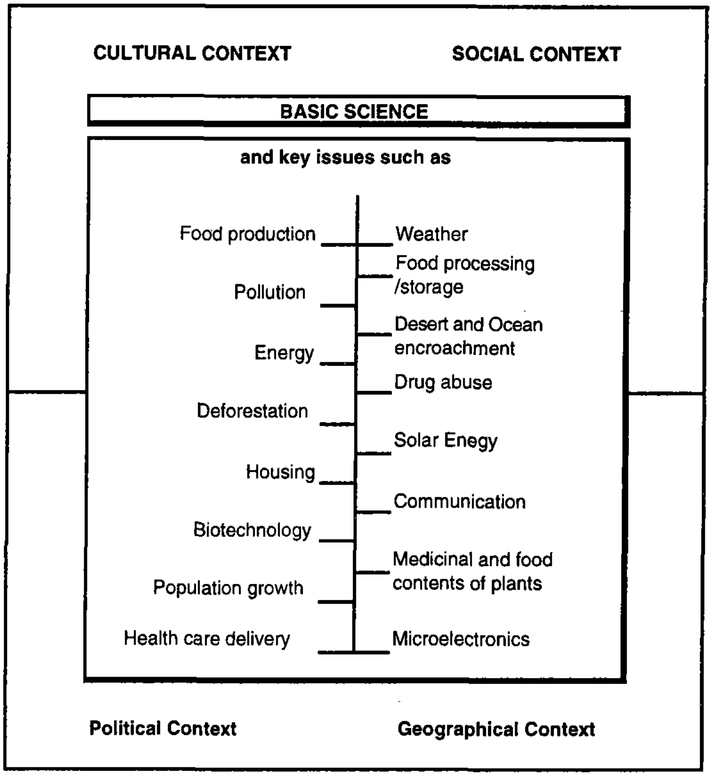

Fig 4 : Science - related issues and contexts to be addressed by a science-education programme for all in Africa

STRATEGIES FOR IMPLEMENTATION: GENERAL

Formulation of a regional policy on science and technology education for all

Through the forum of the Organisation of African Unity or other relevant agencies, a policy on science and technology education for all should be adopted for implementation in member states beginning from 1995. This policy should provide guidelines for ensuring that the machinery at the formal or nonformal levels of implementation of the programme is in place and fully operational.

Establishment of a regional centre for articulating the implementation of the science and technology education for all policy

A regional centre should be established to articulate the implementation of the science and technology education for all policy. The centre should liaise with national agencies, commissions or centres that are concerned with mass literacy programmes which have science and technology components.

Development of a master plan of action

A programme on science and technology education for all is complex in its implementation. The implementation would, therefore, need to be conducted within the framework of a systematic master plan. The objectives of different phases of the master plan should be clearly delineated and the points of input chosen so as to produce rapidly visible results.

Revision/renewal of curricula

In most, if not all African countries, the science and technology curricula are rote-learning and content-knowledge oriented. Unfortunately lacking is the focus on skills that is the hallmark of a science and technology literate person. The existing science and technology curricula are mainly capable of producing individuals who have 'book knowledge' of science and technology, rather than procedural or application skills. Since these skills are at the heart of the concept of literacy in science and technology, efforts should be directed at revising or reviewing existing science and technology curricula to reflect this expected orientation.

Introduction of a compulsory basic science and technology programme.

Basic science and technology should be introduced as a compulsory subject/programme in the primary and junior secondary schools. This can be in the form of a subject or incorporated into existing science programmes e. g. primary science or integrated science. All pupils that are enrolled in our primary and junior secondary schools should take this basic science and technology programme as a certification pre-requisite.

Teacher training and motivation

A massive teacher training programme should be embarked upon for the production of teachers who are knowledgeable in the content and who have pedagogical skills for implementing a basic science and technology programme. Such teachers should be well motivated through job security, incentives, special allowances and regular payment of salaries.

Infrastructural facilities and equipment

The gross shortage of infrastuctural facilities and equipment for science and technology teaching in many African schools cannot be corrected in a few decades. The unfavourable economic situation in most of the countries is a major obstacle to redressing the issue of shortage. Suitable strategies have to be adopted for combating the problem of providing the infrastructural facilities and equipment to support the 'all comers' posture towards science and technology education.

Practicable strategies include the establishment of resource centres and the building of factories for the local production of science and technology laboratory/workshop facilities and equipment. This strategy is in use in Nigeria. A huge science equipment manufacturing centre is in operation. Another is soon to be commissioned. It is anticipated that the daily products of these centres can equip twenty school laboratories/workshops. When production is at full capacity, all the 6,000 secondary schools in Nigeria will be kitted and fitted in no time. These factories also have the capacity to serve other countries in the region.

Another strategy is to expose teachers to courses and workshops in improvisation and use of locally available materials for science and technology instruction. Science Teachers Associations (STAs) and Unesco are actively involved in this exercise. There is the need, however, to step up efforts and investment in the area of improvisation.

Teaching strategies

Cooperative learning within the constructivist tradition should form the core of the strands of strategies for teaching a basic science and technology programme. Cooperative learning is predisposing to the African socio-cultural orientation, facilities limitation and acquisition of knowledge, skills and attitudes in science and technology. The constructivist model which places premium on building upon what the learner already knows through the construction and negotiation of meanings from experiences, is also the emerging strategy for science and technology instruction. Consequently, it is proposed that teachers in Africa who will be given responsibility for implementing a basic science and technology programme should be inducted into the use of a cooperative-constructivist model through preservice and inservice training.

Skills involved in 'learning how to learn' and which will favour the participation of girls in science and technology should also be emphasised in instructional delivery.

Distance learning

The apparatus and mechanism for delivering instruction at a distance should be initiated/improved upon. Within this mechanism, the science and technology component should be tailored towards the objectives of science and technology education for all as earlier outlined. The support system e.g. resource centres and resource persons of the distance learning mode should be strengthened.

Textbooks

The high cost of textbooks and the few number of texts written by indigenous authors have potentials for impeding the success of a science and technology education for all programme. Government subsidy on textbooks and encouragement of indigenous authorship of texts written in the context of local environment should be regarded as priority.

Evaluation

A feedback on how well the objectives of the programme are being met is desirable. Formative evaluation of the science and technology education for all programme would need to be undertaken by agencies, institutions and government. The findings of such evaluation exercises will give indication of how remedial measures would need to be taken early before much damage is done.

ISSUE OF ROLES IN IMPLEMENTING A SCIENCE AND TECHNOLOGY EDUCATION FOR ALL PROGRAMME IN AFRICA

National initiatives

Curricular adjustments and educational structural reforms should be intiated by African countries to support the implementation of the science and technology education programme.

A sizeable budgetary allocation should be given for the implementation of the science and technology education programme by African countries. A major factor between success and failure of the programme is finance. Government should consider scientific and technological literacy as a priority area for funding.

A task force should also be set up to monitor the implementation of the programme.

Governments should make efforts at providing basic nutritional and health needs of the people and economic support for under-privileged families. This will create an environment that is conducive to learning science and technology.

Communities, NGOs and the media should work in close partnership with government and other agencies in the reform of curricula and provision of educational structures for the science and technology education for all programme. It should be stressed that private sector partnership is important in scientific and technological literacy issues. Support is needed from the private sector especially at the technical school level, and for funding.

SPECIFIC STRATEGIES FOR PROMOTING SCIENCE AND TECHNOLOGY EDUCATION FOR ALL

Primary

The primary level is at the heart of a basic education programme. The pyramidal structure of formal education accounts for the fact that the primary level is where the bulk of the schooling community is. The inference is that if primary school pupils are given basic education in science and technology, a sizeable proportion of the schooling community would have achieved scientific and technological literacy.

Thus, a major strategy is to make basic science and technology compulsory within the context of a compulsory primary education.

Associated with achieving this goal are the issues of teacher training and facilities. Institutions preparing teachers for the primary level should include a pass in a basic science and technology programme as pre-requisite for certification. The training of specialist teachers in science and technology should complement this effort.

At the primary school level, facilities should not be a major hindrance to science and technology education. Our primary school teachers, through preservice and inservice courses should be encouraged to use the child's school and home environment as the laboratory for instruction. Teaching from the environment and about the environment should be the goal. Materials that are available in the child's environment should form the core of instructional materials. Learning of science and technology is made real to the child through such practical and homely experiences.

Secondary

Basic science and technology as a subject or as part of an integrated science programme should be made compulsory at the junior secondary level. Specialist teachers will need to be trained in basic science and technology or integrated science to implement such a programme. Many countries in Anglophone Africa are actively pursuing this line of curriculum development and teacher preparation. Since this is a viable strategy towards achieving science and technology education for all in Africa, the Francophone and Lusophone countries are enjoined to consider this option.

At the senior secondary level, special science schools have been found to be a cost-effective way of training future scientists, technologists and engineers. If the factor of facilities is limiting, as is usually the case, the available facilities and personnel are pooled in the special science schools, rather than spread thinly over all schools. Products of the junior school system who aspire towards careers in science and technology take the advantage of such special science schools to become better materials for higher level training in the universities or polytechnics. The special science schools experiment which has been a success in some African countries such as Nigeria is therefore recommended for adoption by other countries in the region.

A strong link should be established between our secondary schools and industry. This linkage should enable industry support science and technology instructional efforts through the provision of workshop/laboratory equipment, scholarships, sponsorships of study tours and excursions.

Tertiary

Although the tertiary level is not regarded as being concerned with the provision of basic education, it is important for the production of personnel who are providers of basic education. For instance, teachers are prepared mainly at the tertiary level for the provision of basic science and technology education in the primary and junior secondary schools. The quality of teachers produced is dependent on the human and material resources available in such tertiary institutions.

In this wise, efforts should be made to improve the human and material resources for science and technology education in our tertiary institutions. African scientists and technologists should be given reasonable inducement and encouragement in order to stem the current brain drain. A strong link between our tertiary institutions and industry will, among other things, help to build capacity, especially in the areas of research and development of technologies that are meaningful, especially to rural communities. Such technologies should be made 'user friendly' to the people.

It is obvious that the culture of maintenance is a factor impeding progress in the effective utilisation of technologies in Africa; Apart from devising general strategies to make people imbibe such a culture, we should aim at producing manpower for the maintenance of equipment in our schools.

OUT OF SCHOOL PROMOTION OF SCIENTIFIC AND TECHNOLOGICAL LITERACY

Out-of-school activities such as conduct of projects should be given priority in science and technology education. Project work should form a key component of primary science, basic science and technology/integrated science programmes; Pupils should be encouraged to undertake projects that are aimed at solving problems related to science and technology in their immediate environments.

All primary and junior secondary school pupils should be encouraged to enrol as members of Junior Engineers, Technicians and

Scientists (JETS) clubs. These clubs carry out activities such as projects, quizzes, lectures, debates, excursions and field trips that are directed at fostering the interest of our youth in science and technology education. This success story forms the basis for recommending the introduction of the JETS concept into the school system of countries where JETS clubs are not yet in existence

Radio and TV broadcast, and feature articles in science and technology in the newspapers can form a media strategy for making the non-schooling community science and technology literate.

CONCLUSION

An attempt was made in this paper to clarify a number of issues relating to the development and implementation at a science and technology education programme for all Africans. The focus was mainly within the area of formal education. Some mention of ways of reaching members of the non-schooling community with a view to making them science and technology literate was made. Project 2000 + a joint UNESCO and ICASE initiave was also highlighted in the discussions on global efforts in the area of scientific and technological literacy.

Funding, lack of good leadership, socio-cultural factors (including ethnicity and tribalism) and political instability are the major problems that can stand in the way of the successful implementation of a science and technology education for all programme in Africa. These problems have been with us for a long time and are major elements of a vicious cycle. It is speculated that education will serve as an erasing force for these problems.

Our leaders should recognise that education is the most potent tool for breaking this vicious cycle. Commitment to the goal of education for all should therefore be *absolute*. It is within this commitment that science and technology education for all should be situated. The prospects of science and technology education for all rests in essence , on the political will of Africans; It is this willingness and genuine commitment that will stimulate external support especially in the form of funding and technical assistance and serve as the major driving force for successful implementation of the programme.

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Chapter Two

TOWARDS A RELEVANT SCIENCE AND TECHNOLOGY EDUCATION PROGRAMME FOR AFRICA

S. T. *BAJAH* *

INTRODUCTION

This chapter starts off with a series of questions which are considered to be pertinent to the discussion of the theme - "Major Elements of Science and Technology Education for All in Africa". The questions were developed in the hope that through them the relevant problem associated with the theme can be identified. Identification of problems constitute a key preliminary in the implementation of programmes especially in science and technology. Ideas in science when formulated into a problem provide the beacon lights which can then be followed to a meaningful end. And so what are the questions ?

Question n°1

Why has science and technolgy education originally formulated for the talented able few become a commodity which has to be delivered to all?

Question n° 2

How relevant is science and technology education to all in Africa?

Question n° 3

What resources (human and material) will be required to deliver science and technology education to all in Africa.

More fundamental to these questions is an issue which always crops up when a theme such as is presented to us is discussed among science educators. Are we to refer to a package -"science and technology education" or to consider education through science and technology? Are we to consider science education and technology education as subsets of that package? Where do these fit into the now popularised science and

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for public understanding of science and technology? What is the PROBLEM ?

Science and Technology Education for all - traditional v/s contemporary models

The traditional model of science and technology education assumes that its central purpose is 'to put youngsters on the road to becoming research scientists and engineers' (Gilbert, 1989).

This road runs, for those who choose to follow it, through formal education. Traditional science and technology education concentrates its attention on those youngsters who may become motivated to pursue science and technology in the longer term and who have physical energy and mental skills to grasp the ideas involved. In practice therefore, this means that such science and technology education is designed for the benefit of 20 % - 30 % of youngsters. So even at the formal level, the traditional model caters for a disproportionate percentage of the learners.

The contemporary model on the other hand starts with an assumption that all science is teachable to all pupils in some intellectually honest form and that "all science is learnable by all pupils". It then goes on to make the distinction between 'scientific literacy and competence for all, and scientific expertise for some'. Even here, the contemporary model sees scientific expertise for some and not for all. At this point then, we can attempt to examine the first question :

QUESTION 1

Why has Science and technology education originally formulated for the talented and able few become a commodity which has to be delivered to all?

In trying to answer this question, let us relate it to Africa. It is a well-known fact that Africa cannot exist in isolation and that scientific and technological advancement in the developed world make impact on Africa. On its own, Africa cannot participate in world activity without getting involved in science and technology for, as a renowned educationist in Africa put it, any country which "ignores science and technology does so at its own peril". So much has gone on in science and technology in the world that if Africa is to participate in such advancement, there will be need to involve all Africa (in varying degrees) so that science and technology can be seens as tool for advancement. In many African countries, the main source of education in this modern day and age is the formal system. It is in the formal system that the beginnings of science and technology education for all should be introduced. Based on that thesis, an attempt should be made to develop relevant science and technology education programmes that will be suitable for all students going through the formal education system. Some developing countries have already set up 'Working Parties' to examine the past and from there develop programmes in science and technology education that will carry them into the twenty-first century and beyond (see for instance Mauritius Master Plan for Education for the year 2000). Because now there is so much to learn in the formal school system, the science and technology education programme for all should be such that will broaden the horizon of the learners in a way that thereafter, they will be confident to embrace science and technology and develop positive attitude to science and technology whether they continue with science or not. It is that type of science and technology education programme that this Advisory Committee should urge and advise African governments to pursue. The move towards education for all also underscores the need to provide access to formal education for a large majority of school age children. Science and technology education programme for all must begin at the primary level and be sustained throughout the formal school system. Let every African country take a critical look at its primary science programme so that it can be made available to all the pupils in a way that they will be turned on and see science as a way of living. The implication here goes beyond good and relevant programmes to :

- Primary school teachers and their training for science and technology teaching;
- Provision of adequate facilities for interactive process based learning of science at all levels; and
- making the home and environment conductive for the practise of science and technology.

Outside the formal education system, there is a large number of the population that will need to be adequately informed about science and technology to the point where they consider themselves educated. Science and technology education outside the formal system has always been controversial. - the attempt as has generally been pointed out should be to make the public out there be aware of science and technology along with their limitations and potentials. The whole approach to science and technology education at the non-formal level is underscored by the approach to 'Public Understanding of Science'. (See CASTME Journal, Vol 12 No.3, 1992).

Returning then to the question raised, the gains in delivering science and technology education to all in Africa are so compelling in this day and age when science is to be perceived 'as an adventure of the human mind'. Africa must now begin to develop and test educational programmes which deal with science, technology and society - a need for all.

QUESTION 2

How relevant is science and technology education to all in Africa?

To help us answer this question, we must fall back on the discussion advanced to answer the first question. It is perhaps easy to dismiss this question by arguing that because science and technology dominate our lives, we should all, including Africans, just accept it as a "sine qua non for living. But I imagine the spirit behind this question is one which has plagued Africa and may continue to do so if care is not taken. Which science and technology are we referring to here? Whereas science appears universal as a concept, technology, the supposed application of science, has to be relevant and appropriate. The universality of science makes it possible for the African child in the remotest village to do science in the real sense of the word. Africa is abundantly blessed with science - science from time immemorial. But the problem in many African countries has been that science is presented as an imported package, foreign to the African. And yet it has been well demonstrated that science as an adventure of the human mind can take place anywhere including Africa. There is science in Africa but let no attempt be made to refer to that as African science. Science even at the primary level, can be effectively taught and enthusiastically learned in any African environment. Relevant science to all in Africa should be that which enables the African to understand the immediate physical environment and to understand and interpret nature scientifically.

However, when we address this same question to technology education, there is need to caution that not all existing technology is appropriate to our needs in Africa. In our bid to provide technology education to all in Africa, there will be need to isolate and identify the technology involved in many of the activities practised in Africa. When an illiterate African woman in the riverine parts indulges in the distillation of 'gin' from local raw materials, does she know she is involved in technology/Technology education for all should be extended to explain the science processes involved to that woman and many more like her so that they can begin to think of how to improve on their products because science and technology are not static. To achieve technology education for all in Africa, very determined effort must be made to explain activities in Africa in terms of the principles of science and technology, if need be in the vernacular. The following are focus areas:

* The technology involved in production of local food;
* the technology in the production of cloths and clothes;
* the technology in the use of local materials for building;
* the technology in converting plants-leaves/stems/ roots. Into very effective drugs.

In trying to explain all of the above, the African should then be gradually led into Western technology in a way that improvement can be effected in what is already available. Unless such an approach is adopted there will be the usual tendency to grab the latest technology in the Western world in utter disregard for what is already in place.

Science and technology for all in Africa must then address the various needs of the wide spectrum of Africans. From the illiterate to the educated - science and technology must be presented at different levels. The sophistication which the computer has brought to every day living will be meaningless if presented to people without the background and need for its use. In tackling the key elements of science and technology education for all in Africa, this Advisory Committee must come to terms with aspects suitable for and relevant to:

I. Pre-school children
II. Primary and secondary students
III. School age children not in formal school systems
IV. Literate adults in large cities
V. Non -literate male adults in rural parts of Africa
VI. Non-literale female adults in rural parts of Africa..

National Working Parties to tackle key elements of science and technology for all in Africa should be encouraged with a time frame of between now and the beginning of the twenty-first century (2000+). The need for such science and technology working Parties to collaborate with existing National Education for All Committees is most urgent now. This Advisory Committee should then act as facilitator to the national committees on science and technology education, and through it competent resource people across Africa can be identified and supported.

QUESTION 3

What Resources (Human and Material) will be required to deliver science and technology education to all in Africa?

Resources for science and technology education for all in Africa must be tackled in a meaningful pragmatic way. One reason why science and technology has been badly taught in many formal systems in Africa is the lack of proper resources, both human and material. This presentation does not attempt to re-state the obvious; the scenario in many African countries is very well known. The quality of science and technology education to a large extent depends on how it has been resourced.

There is need however here to draw attention to aspects of resources that will be needed to deliver science and technology to all in Africa including the non-formal mode. For a long time the news media has been used in many countries to communicate science to the public at large but it has become obvious that those who benefit from for example the print media are those already literate. That group is not representative of many African countries today. The larger neglected group will be the target of a good science and technology education for all. How should such groups be reached?

The ability to communicate science and technology depends to a great extent on one's knowledge of science and technology. In the past, the few African scientist have not taken the challenge of communicating science to their immediate public - perhaps because the audience is too diverse or just that they do not feel the need. But now that science and technology education is to be delivered to all in Africa, the African scientists should be prepared to make presentations to:

* African women village groups
* Non-literate village heads
* Semi-literate out-of-school children

One prevalent problem that has been identified in making the above suggestion is that the good African scientists by and large are not usually fluent in the vernacular that the non-literate Africans understand.

And those usually fluent in the vernacular are not usually the scientists. This problem is compounded by the large variety of African languages and distinct dialects. Nevertheless, the following will be useful resources to underscore :

* African scientists who can communicate in local language
* Trained teachers of science and technology
* Adequate supply of science and technology equipment to schools
* Non-syllabus science and technology print materials for children in Africa

The charge to scientists for public understanding of science was succinctly made by the Royal Society in London. That same charge can be extended to African scientists:

"Learn to communicate with the public, be willing to do so, and consider it your duty to do so"

Current Activities of the Education Programme of the Commonwealth secretariat and possible areas of collaboration with UNESCO-BREDA

One key area of concern in science, technology and mathematics education is effective teacher training. It is a well-known fact that many primary school teachers feel insecure teaching science. Its either because they themselves did not have adequate training in the teaching of science or just because they are faced with inadequate facilities in their various schools. The Education Programme (EDP) of the Commonwealth Secretariat (COMSEC) has therefore focussed attention on the improvement of teacher training for Science, Technology and Mathematics (STM) education. With the ultimate goal of improving the quality of STM education, the project has taken the route of a planning meeting after which regional workshops will be held. The target group in these workshops will be the trainer-of-trainers (TOTs) in Colleges of Education where primary school teachers are trained. With a crop of well-trained STM teachers, their teaching will be good to the extent that more children will be turned on to science.

Another concern of EDP is in the area of initiating more girls and women into STM. There is abundant research evidence to show that more girls than boys shy away from STM. The project on attracting girls and women into STM has been conducted under the titles "Science, Technology and Mathematics Clinic for Girls" and the "Science

Technology Roadshow". (see EDP video film titled Righting the Imbalance).

The two projects described above would help to deliver STM to children and girls who constitue a fair proportion of the 'all' in science and technology education for all in Africa. There is ample scope in these two projects for collaboration between UNESCO and COMSEC. The Advisory Committee should see EDP as a partner in the area of delivering STM to all in Africa.

Modalities can be worked out on collaboration in workshops and interactive projects. For instance, COMSEC through EDP is already collaborating in the PROJECT 2000+ with UNESCO and the International Council of Associations for Science Education (ICASE).

CONCLUSION

In concluding this paper, it is pertinent to recall that modern society is science and technology based. So many of the policies that are thrust upon us by the various bodies depend on science and technology and many have major effects on our prosperity and on our everyday lives. There is a scientific and technological revolution all over the world, but if we are to achieve the benefits of the revolution, we must in Africa have a scientifically literate population "that is ready to accept and exploit the fruits of science and technology".

The Advisory Committee should address the following issues in its attempt to deliver science and technology education to all in Africa.

- Early introduction of 'good' science into schools
- preparation of STM teachers for effective delivery of the subjects
- availability of support STM materials (print and non- print)
- need to focus attention through science and technology on the physical environment in Africa
- communicating science to all so as to achieve public understanding
- support for indigenous technology and relevant technology.

The above are some key areas of concern of science and technology education for all in Africa. Very determined effort has to be made to dissuade Africans from accepting science and technology with suspicion. However, care must be taken not to import technology that will dramatically make Africans redundant in their place of work.

In advocating science and technology education for all in Africa, the broad spectrum of the target groups must be considered:

- The formal school population - science and technology should be an integral part of the primary and secondary education of all children
- The out-of-school population - children and youth who should have been in school under the universalization of education process
- The work force, including vast numbers of functional illiterates
- The educated adult section of the population
- Girls and women that are usually marginalised
- The handicapped in the population.

When all of the above target groups are provided for in a programme of science and technology in Africa, there will be some hope that the twenty-first century will be scientifically and technologically fruitful to Africa.

Some Recommendations

A number of Recommendations are being made here to UNESCO-BREDA through the Advisory Committee:

1. The Education Programme of the Commonwealth Secretariat should be given an 'observer status' in the meetings of the Advisory Committee.
2. Training manuals and possible classroom manuals for STM be developed and trial tested before wide distribution in countries in Africa. Names of possible contributors can be considered during this meeting.
3. In collaboration with the Commonwealth of Learning (COL) through EDP, distance learning materials already available for STM should be acquired and distributed in Africa through the Advisory Committee.
4. Identified training videos for STM like those produced by EBS should be acquired and widely distributed in Africa. There might be an opportunity for members of the Advisory Committee to be involved in the production of newer titles.

(EBS = Educational Broadcasting Service Trust)

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Chapter Three

A COMPROMISE CURRICULUM FOR SCIENCE AND TECHNOLOGY EDUCATION

Marianne *NGANUNU**

It is now becoming evident to an increasing number of educationists that the education designed as it was, for the academic elite, cannot be applied in the same form when educational opportunities are opened up to the whole population. At the same time there are educationists who prefer to see mathematics taught in its traditional form and who fear that science might be polluted by the inclusion of technology. Faced with these two contrasting views, many countries, Botswana included, have ended up with some 'compromise curriculum' This is a curriculum that includes some purely academic material which is regarded as an essential preparation for those who proceed for further studies as well as some real-life skills and topics which have been put in to cater for the early school leaver - which in most African countries will constitute the majority.

The end result is that some parts of the curriculum, i.e. portions that exclusively prepare for higher academic studies such as transformations in mathematics and using a pipette in science, are of no value to the majority of students. On the other hand, it is difficult to identify a part of the curriculum aimed at the early school-leaver which is not also relevant to those who proceed for further studies, be it fixing a bicycle or learning how to open a bank account.

'Education for all' does not merely refer to making school places available to all, but to making *education* available to all, i.e. providing education that all can benefit from. An education for all programme, including a science and technology for all programme, should cover knowledge and competencies - *all of which are relevant to all students.*

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The outcome

To identify the key elements of any education programme the desired outcome must be well defined. This will vary from nation to nation, but some broad goals may be applicable to the whole of Africa.

The World Declaration on Education for All (WDFFA) defines education from the individuals point of view and states that education should provide the tools, knowledge, skills, values and attitudes 'required by human beings to be able to survive, to develop their full capacities, to live and work in dignity, to participate fully in development, to improve the quality of their lives, to make informed decisions, and to continue learning' (WCEFA, 1990).

At the national level the goals may be more specific. 'Governments are insisting that education in general, and science, mathematics and technology in particular, should play their part in improving national productivity and enhancing the employment prospects of young people' (Power,). For example, the Botswana Government states as one of the objectives of education 'to prepare children for a useful, productive life in the real world' (Botswana Government, 1990).

Education must lead to the *ability to earn an income*. Without the ability to earn an income the problems related to poverty, dignity and quality of life can not be solved. This of particular importance to our continent where poverty is still common and unemployment rising.

What role can science and technology play in this context ? Everyone, in their daily lives, comes into contact with science and technology. People who cannot use and understand the available technology are left behind in development and in the competition for survival - both as individuals and as nations. But it is more than that. The youth also have to prepare for the technologies of tomorrow and the development that results from these technologies. 'The world we live in is dominated by change related to development' and 'the pace and volume of change are constantly increasing because of science and technology'. Today's young people must 'keep up' with this change; they must be prepared for technology that has not yet been invented, and be able to design solutions to problem that do not yet exist. (ICASE/UNESCO/COMSEC/1992).

A New approach to curriculum development

A common approach to curriculum development is to look at the existing syllabi and see how they can be revised in the light of changing objectives. This, in the best of cases, can only lead to a 'compromise curriculum'. In moving from an education designed for the elite to an education for all programme, the whole education provision must be viewed with a 'expanded vision' (WCEFA 1990). The first and foremost criterion must be *to provide education that people can use.*

This would involve identifying what people do in their daily lives and also what they need to do in order to achieve the WCEFA goals or the equivalent national educational goals; then identify the tools, knowledge, skills, values and attitudes required to reach these goals. Only after the desired objectives have been identified, would it be appropriate to identify the subjects or subject areas required to provide this education. This approach is important especially as many of the new components of education either cover a whole range of subjects or may not fit into any of the existing subjects. New educational goals might lead to a combination of existing subject or the creation of new ones.

Science and Technology might be one of these new ones. A science curriculum that deals with real-life issues must by neccessity have a large and significant component of technology as the applications of science are technical (Nganunu, 1991). The UK National Curriculum Science Working Group expresses it thus 'technological applications.... can often provide contexts through which scientific concepts can be more effectively introduced and developed'. Technology, on the other hand, which involves devising practical solutions to problems relating to human needs, draws heavily on the knowledge and skills of science. (UK National Curriculum,)

To ensure that the curriculum meets the need of the individual in a particular society the curriculum must be developed from within. The era of inheriting, copying, or adapting foreign curricula - until recently a common approach in Africa - must surely be gone by. The experiences of other countries will come in at a later stage in the curriculum process, for example, when ideas are needed on how to impart a certain skill or how to handle a new technology, for example, computer education.

Science and technology for all

A science and technology for all programme must prepare for *change*. The focus must therefore be on *development skills*. The skills will not only help students to find out, understand and use the scientific knowledge and technology to today, but also to find out, understand and use the scientific knowledge and technology of tomorrow.

Skills, however, cannot be taught without a context. This context should be of the scientific knowledge known today and the technology be as it applies today to everyday situations in the community for which the curriculum is being developed.

The broad areas of science and technology that relate to survival and quality of life, and hence should be included in a science and technology for all programme, are *(i) health, (ii) the environment, and (iii) technology*, and this include food and agriculture in the environment area. By analysing the daily activities of people, in their homes and at work, the most relevant context areas can be identified.

It is of outmost importance that these skills are taught in a familiar context. For a student to engage in any kind of inquiry or problem solving activity, he/she must work with issues and materials that are familiar and easily accessible. If the task is an environmental problem, the problem should ideally be one that affects the immediate community and the solution should be one that same community can use. The benefit to the individual and the relevance to real-life should be apparent throughout.

The basic skills required are very much the same for all people.

For example:

- Whether you are running a small business from home or a large manufacturing plant, you need the ability to *adapt* to current demand, *communication* and *inter-personal skills* to sell the goods, *plan* your work, *evaluate* your methods, and make *use of available technology* to increase productivity.
- Whether you depend on subsistence farming or intend setting up a large agricultural project, you need *initiative and self motivation* to get started, you must *reason* and *make decisions* on what and where to plant, maybe experiment and evaluate methods, solve problems etc. before a successful result is produced.
- To make an informed decision, be it where to position a pit latrine or how to dispose of city waste, you need *knowledge of the factors*

involved or *knowledge of how that information can be obtained*, you need to *think critically* and *reason* before *making a decision.*

The above examples demonstrate that the basic skills required by people are very much the same whether for a literacy participant, an early school leaver, or a highly educated person. These are skills that all people require in their daily lives, at home and at work, and hence should be taught in a science and technology for all programme.

Many of the real-life skills - communication, creativity,thinking, taking responsibility, decision making and so on - are not specific to science and technology. However, science and technology can contribue to the learning of these skills. For example, take an important topic like health. The most important aspect relating to quality of life is how to maintain good health for oneself and one's family. In a science and technology for all programme it is therefore necessary to go beyond the academic content of a standard biology textbook on, for example, the structure and function of the heart, and ensure the curriculum provides useable advice on nutrition, exercise, smoking and so on. And since such information could change with new scientific discoveries, the emphasis should not be on 'the right answers', but how to find out information, research into current opinion, discuss the issues, make your own judgement, and take responsibility for your own health.

Other life skills are best taught through science and technology. For example, environment and agriculture provides excellent vehicles for learning skills of scientific inquiry, and the technology for solving problems.

A scientific inquiry into the cutting of trees for firewood or the introduction of a new industry into the local community, would provide students with skills of 'systematic observation, making and testing hypothesis, designing and carrying out experiments,... drawing inferences from evidence, formulating and communicating conclusions', and so on (UK National Curriculum).

A technology problem-solving activity, such as producing brick of best possible quality with locally available materials or finding a way to water a vegetable plot with minimum waste of water, would provide students with skills of thinking, planning, designing, experimenting, evaluating and producing. Being able to find solutions to identified problems is the only way students can develop problem solving solution for the future..

By emphasising development of skills, the real-life context, the opinions of and the benefits to the individual, and by personalising the experience, there is a greater chance of instilling the values, attitudes and behaviour that contribute to personal fulfillment and lead to responsible participation in the community.

Providing a variety of abilities

Any education programme must start out where students are, i.e. be based on the knowledge they already have and match their conceptual level. This of course varies within any group and, as learning goes on, some progress faster than others.

Therefore, within any science and technology for all programme, there must be scope for individualisation and special needs. For example, 'communication' is a tool every student must acquire, but this does not mean that every student will learn the same thing in the same way or reach the same level of competency. There should be a lot of flexibility in teaching/learning methods to accommodate the different abilities and interests. There must be opportunities for advancement for the fast-learner as well as stimulating activities for those with learning difficulties.

In technology, a problem-solving activity could range from being a very elementary one of purifying drinking water to a very advanced one of programming a computer to control a process. By allowing students to 'identify for themselves a problem that is interesting and worth investigating, or to design the procedure to be adopted', interest and commitment will be increased (Hodson, 1990) and, although the learning activity - solving a problem - is the same for all, the content (the problem) is adapted to the conceptual level of the learner.

Further individualisation can be achieved by allowing students to set their own short-term educational goals - guided by the teacher - and then attempt to reach these goals. This is also a way to develop self-motivation and responsibility for oneself Students could make their own work plan, based on ideas provided by the teacher as well as on their own, and are then assessed on their ability to carry out what they had themselves planned to do.

Assessment

An 'expanded vision' on education assumes a similar 'expanded vision' on assessment. There has been considerable curriculum innovation in primary school in Africa since the SEPA initiative, but the implementation of curricula has been restricted by assessment. Young pupils are often allowed to engage in fairly open-ended investigations and simple project work, but as they move higher up teachers are forced to change the teaching methods in preparation for the school-leaving examination. The examination, in most cases , tests content and knowledge of pre-dtermined experiments – not research skill, independence, self-motivation and the like.

According to Hodson, to remove this opportunity for unstructured personal investigations from the students 'at the very time of their lives when they are struggling to establish their individuality' leads to loss of interest and enthusiasm for the subject. He states that 'the motivation of older learners often requires a cognitive stimulus, such as the exploration of ideas, the investigation of inconsistencies or the confrontation of problems' (Hodson, 1990). Our highly examination oriented education systems does not allow for this.

The whole issue of assessment must therefore be reviewed in line with an 'expanded vision' on education.

CONCLUSION

Will a science and technology for all programme put students who are proceeding for further studies at a disadvantage? This of course depends to what extent teachers can individualise the teaching so that students can develop at their own rate. However, a science and technology for all programme which focuses on skills development is likely to provide a better foundation for further studies than the traditional approach of exposing students to academic content matter at an early age.

In a recent study on human resource development for post-apartheid South Africa one of the problems identified as a cause for the high university failure rates in science and mathematics (including students from well-equiped schools) was the 'narrow academic education' provided in schools which fails to produce 'creative thinkers'. (Swainson, 1991).

Regarding the real-life skills, it should be remembered that even those who proceed for further education eventually have to enter real-life and the world of work. 'Even the high-technology scientist needs to relate to real-life and, in particular, to understand how technology affects the environment and society' (Nganunu. 1991)

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Chapter Four

SCIENCE AND TECHNOLOGY EDUCATION FOR ALL: MAJOR PSYCHOLOGICAL AND SOCIOLOGICAL CONSIDERATIONS

Magnus *J. A. COLE**

Science and technology education (STE) for all in Africa must take into consideration the developmental needs of the individual and that of society. One has to consider the subject at the local and regional levels to the extent that it relates at the local level, to the developmental needs of the individual, the local community, and the society at large; and at the regional level, one needs to consider the sub-regional aspects of individual as well as the continental relevance.

Similarly, in considering the societal relevance of STE, it is necessary to examine the society in the context of the micro-society being viewed at the family and local small community level, and at the national, sub-regional and regional level. One would accept that indigenous African communities provide and maintain their own level of implementation of science and technology from as early times as the society has existed. Such societies possess within individuals and within their cultures their own paraphernalia of science and tehcnology such as may be related to growing their own crops, maintaining their environment, regenerating their own population, and taking care of their health through herbal treatments. All that is possessed within such societies may be viewed in the modern context as being primitive ; and their needs now would be considered in terms of upgrading the events in such societies to match what is appropriate in the modern context. One would imagine therefore that the individual needs in STE could commence with the individual and extend to the small society within the context of community and individual well-being.

At the societal and national level science and technology needs will be explained in terms of liberating present day African societies from the ills of ignorance, superstition, poverty and hunger, disease, and lack of basic amenities of housing, transportation, communication, and adequate

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infrastructure befiting a modern society of the twentieth, going on twenty-first, century. In addition however, such emerging societies need to be aware of the environmental disasters that are concomitant with modern industrial and high technological development that is ruining the human environment and making the planet earth almost unlivable. Such ills of course, include the depletion of non-renewable energy sources, pollution of the earth with toxic wastes depletion of the ozone layer through the use of CFC's and global warming. These disatrous effects on the environment are the costs of modern development which have been caused, to some extent, by the unbridled desire for progress irrespective of the health, or aesthetic effects the bye-products of certain developmental processes would have on the environment, on individuals, on wildlife, as well as posterity.

THE CONCEPT OF SCIENCE AND TECHNOLOGY EDUCATION FOR ALL IN AFRICA

The concept of STE for all in Africa should not be seen as a frivolous concept for the African. The african group, whether race, tribe, or culture has maintained and sustained itself ever since the beginning of time. The origin of H.sapiens had been traced to the African continent for a long time, although lately other claims have been made due to recent archeological findings. However in every society there are modi operandi with regard to the basic activities of existence; and these activities deal with aspects of life and society that can be identified and compared between societies in the technologically developed society and the not-so-developed societies of the third and even the fourth world. As we are all aware every society has been providing for itself the basic needs of food, health, shelter, and energy, and even communication. What is different is the level at which such facilities are provided, and the sophistication with which these needs are met. There are evidences now that some aspects of the indigenous practices of modest societies can be borrowed and incorporated into the repertoire of the technologically advanced societies..

The concept of science and technology can be identified with the African continent since the time of ancient Egypt, the Nile Valley, and the Nubians. Recent study and reflections are beginning to show that long before the ancient Greeks and the Romans, civilizations in Africa had achieved high levels of technology, obviously based upon their understanding of their natural and physical environment. Studies are also beginning to indicate that the pharoahs of Egypt were black, and their cultural artifacts included principles and applications that reflected high sophistication in astronomy, architecture, land surveying, agriculture and irrigation, medicine and health matters, not excluding cultural, ethical, and spiritual matters. The pyramids of Egypt are examples of how, on the African continent, man was trial-testing scientific and technological principles that defied the known laws of nature. And such feats of human imagination caused ancient great scientists such as Pythagoras, Archimedes, among them, to study under the ancient Egyptians. It is even reported that Theophrastus, Dioscorides and Galen consulted annals of Imhotep in the Memphis Temple Library until second century A.D. when Egyptian medicine influenced Greek medicine.

Studies carried out already in technology, indigenous to the local culture, reveal a high potential, for developing the human mind and innumerable skills to promote human development. Many activities in indigenous technology reveal scientific and technological principles and practices that will be more than appropriate for the human sector of developing countries that would not participate in modern science and technology or benefit from the outputs of modern and high-technology.

The scope of human needs for development in the developing countries are many and varied. As such these varied needs would require varied solutions for their problems; therefore both the hoe and the computer may be appropriate as technologies to apply in the human situations in the developing countries of Africa. This perspective places in full view the relevance and appropriateness of the need for science and technology for all in Africa.

THE ROLE AND PLACE OF INDIGENOUS TECHNOLOGY

As a common facet of everyday life, indigenous technology is as familiar to the African child in his home environment as modern technology is familiar to the average child of a technologically advanced country in his own home environment. The African child is familiar with the materials and processes of a particular indigenous technology in the community; perhaps the child operates the technology as the western child of an affluent family might operate a micro-computer or similar hightech with which the child is familiar. The familiarity of such technology would provide the basis of interest, relevance, and concern necessary for the child to become involved in learning about the technology, and the scientific principles and processes involved. This situation is unlike the present situation in which an African child in an improverished situation is required to learn formal science from processes that are completely foreign and therefore abstract to him.

There are many an African child who had to learn abstract science from teachers who themselves might have been ignorant of the processes they were teaching. Such students similarly became virtually ignorant scientists who could hardly make any impact on the development of modern science and technology in their own environment. Some such scientists and technologists find themselves in advanced countries with the necessary facilities to pursue advanced work; and many an African scientist is contributing to advancing the horizons of science outside Africa, thus contribution to the brain drain from the scientifically and technologically backward Africa that seem to benefit but not to contribute to the modern advancement in the fields of science and technology. It is therefore presumed that in initiating the study of indigenous technology for the African child in the early stages of formal education, the interest in science would be stimulated and the appropriate attributes required for STE learning would be developed to the highest level. The knowledge, skills and attributes that are commensurated with successful science teaching will be developed not only for formal education, but be capable of being incorporated into one's general attitude to life and living. This is unlike the current situation in which what is learned in science is so far removed from one's immediate environment. The remoteness of activities in school science today contributes to the extent to which school activities are divorced from one's everyday life, therefore encouraging the exclusion of what would be positive learning in school from everyday life. It is common knowledge that even reputable African scientists may hold superstitious beliefs common to the uneducated indigene, thus showing that there could be a divide between science and superstition for the African scientist.

One would expect that doubtful beliefs held in the African cultural context can be studied in indigenous technology thus facilitating the investigation of certain beliefs leading to the eradication of various taboos that are predominating and inimical to our physical and cultural development.

The role of indigenous technology in formal education is even more pertinent in the non-formal sector in which the expected improved indigenous technology and its educating and training aspects will contribute to greater understanding and improved output of the traditional technologies. Skills and attitudes will be promoted that would contribute immensely to the individual and community development. Already much work has been done by various groups in Africa and abroad to upgrade indigenous technology to appropriate technology in order that practices become appropriate, more efficient, and in some cases more hygienic. These improved technologies are more readily accepted, understood, and can be more readily maintenanced by local expertise.

Indigenous technology in the curriculum of STE for all will contribute to the emancipation of the African woman in the field of science and technology for development. So far, the African girl is less involved in science and technology because of the distance of science and technology items from her immediate needs and environment. Early experience so far, indicate that girls at the secondary school level studying indigenous technology as the basis of a foundation science course are developing more positive attitudes to science and their cultural practices involving science and technology.

OTHER ELEMENTS OF STE FOR ALL IN AFRICA

Having defined the concepts of STE for all Africa from the African context, and introduced the role of indigenous technology in STE it is then necessary to indicate and, in certain aspects, compare those elements required for STE in relation to conventional STE and that involving indigenous technology.

Initially matters to be considered should include :

- Making STE relevant;
- Provisions of materials for STE
- Defining content for STE.
- Cost-effectiveness of STE for all.

(a) Making STE Relevant

It is necessary to consider the target group for whom materials are to be prepared in order to identify concepts, instructional materials, and methods of teaching. STE should be relevant at the pre-primary, primary and secondary levels of education. STE is relevant in developing knowledge, skills, attitudes and propensities; and these may be specific for specific target groups in terms of what is taught, and how it is taught. And the materials required would depend upon the concepts taugth and the purpose of instruction.

Unfortunately, today in the African context, one finds a lot of irrelevance of contents and materials to the purpose or objectives of teaching. In such circumstances, the experience of the learner and the nature of the physical and cultural environment, are inconsistent with the purpose for which the instruction is intented.

STE for all needs to be structured so that there could be a mixture, of modern as well as indigenous or appropriate technology. Traditional or indegenous interpretation of natural occurences should be analysed in conjunction with conventional interpretations or science of such events. Already relevant aspects of science and technology within the African context are being identified at the tertiary level, as graduate research is being encouraged on the local environment.

(b) Provision of Materials for STE for All

Instructional materials are required for the teaching of conventional science or indigenous technology related science. There are course contents and details of aspects of STE for All which need to be developed in areas such as why we teach STE, what to teach, how to teach, and how and what to evaluate. In addition there are equipment, apparatus, visual and other aids that may be required to facilitate learning.

Current experiences in science curriculum development and teaching in African countries indicate that most African economies can hardly support the amount or the extent of materials required for input into instruction at almost all levels of education. The primary and secondary levels of education are usually sacrificed to the advantage of higher levels when financial allocation has to be provided for science and technology education, on the pretext that the higher levels of education are more productive in terms of developing skilled and semi-skilled manpower. Such contention however, overlooks the need for developing at the lower levels basic skills, knowledge, and attitudes that would facilitate better and more superior understanding at the higher intellectual levels. On the long run therefore, sound scientific foundation need to be developed at the lower level for more efficient learning later on.

Intructional materials and adequate investments should be made available for the development of appropriate curricula for STE for All in Africa. Exploration of concepts should be facilitated for the purpose of developing intellectual and scientific skills, and less reliance should be given to the transmission of contents of facts as is usually the case in formal science teaching in the improverished economic environments in the developing countries. It is even forgotten in science classes in such environments that the initial stage of development of most scientific concepts begin with practical experience with the senses. More so, initial perceptions of such concepts later differ from later perceptions due to accumulated experiences and further maturity in understanding related to such concepts. With the changing perceptions of scientific concepts with time, the evolving nature of scientific concepts must be acknowledged. Teaching facts of science without providing sensual involvement for the learner is incompatible with the spirit and philosophy of scientific understanding, and the development of correct scientific attitudes.

At first glance it would seem that this problem of financial allocation for provision of instructional materials for teaching indigenous technology in the context of STE for all in Africa will be ameliorated due to the fact that most materials required for science teaching at the lower levels will be immediatly available, and familiar to the learner and the environment. More opportunity for improvisation will be fostered and the little fund available would then be allocated for the higher levels where more sophisticated and unfamiliar materials may be needed, without depriving the lower levels of required funding. It is being suggested that indigenous technology and its related science will make STE for all in Africa more meaningful, more realistic, and more readily feasible in transforming Africa into a scientific and technological culture.

(c) Defining Content for STE for All Africa

Preliminary work by the author in defining the content in indigenous technology indicates that the African culture deals with processes and activities that encompass the various branches of conventional science, such as biology, chemistry, physics, geology, astronomy and so on. Some of the processes may be related to processing raw materials to produce required finished products. In such instances the raw material provides the opportunity for studying the particular item. The biological chemical and physical principles may be examined in addition to the mechanics of the processing that may be required to transform the raw material to the finished product.

In the process of outlining the qualitative aspects of certain processes, the need will present itself for quantitative analysis of such processes, and its effect on product quality.

Therefore the mathematics will be seen as an integral aspect of science and technology, and will no longer be viewed as unnecessary intrusion of quantitative exercice into science activities. The outcome of such relationships will be more readily appreciated than that which is experienced in conventional science classes where the science as well as the mathematics are series of abstractions that have no meaning for the learner whose culture is usually not as accurately quantified as activities in the normal science classes.

(d) Cost-effectiveness of STE for All Africa

The extent to which various aspects of this presentation has elucidated the relevance of indigenous technology to developing a scientific and technological culture should be an index of effectiveness of this aspect of the African environment in STE for All in Africa. The history of western science will itself show that the seeds of modern science were sown in the indigenous technology and experiences of such cultures. And modern science has evolved from the studies and thinking that were invested into unravelling the mysteries that were detected in those technologies and experiences.

In the case of developing countries, most of these countries were either secluded from the external worlds or colonised by western nations that failed to further the development of the respective indigenous culture but instead decided to supplant the indigenous with the colonial culture, thus stultifying the development of the indigenous culture. In terms of acculturation, the indigenous culture will be set on this path of evolution from which it had been diverted centuries back.

Beside the cultural aspects, scientific and technological learning will become a natural output of the physical and material environment identified with the learner rather than being borrowed aspects from an unfamiliar environment. The scientific concepts will be familiar and readily discernible being that they are aspects of the immediate environment and not of a strange and remote environment. Materials for the study of relevant concepts will be readily available, and not necessarily requiring unavailable foreign exchange to obtain them. At the primary and secondary level it will be the case of materials being readily available; whereas at the higher educational level materials will be more relevantly selected to fit the purpose for which respective learning materials will be put.

CONCLUSION

Science and technology education has made it possible for man to recognise problems of the environment as being solvable with the proper understanding of these problems, and having the necessary skills for problem-solving. By incorporating STE as a normal aspect of learning for all in the African environment, learning will become a part of regular activity of the cultural environment, and not somehow separate from one's immediate environment. A consequence of this relationship will be the acceleration of the effects of productive learning through science and technology that may eventually be reflected in the cultural and physical environment of traditional Africa as is reflected in the environments of the modern societies.

Chapter Five

SCIENCE AND TECHNOLOGY AS ESSENTIAL ELEMENTS FOR BASIC KNOWLEDGE, SKILLS, ATTITUDES AND VALUES DEVELOPMENT

Magatte *THIAM**

Further to the Jomtien Conference (Thailand 1990) the problem raised regarding education systems was to achieve Education for all. Within the framework of this Education, Science and Technology occupy a place of paramount importance due to the role that science and Technology play in the development of societies, especially in developing countries and, to the complex nature of their process of development and learning.

Before the Jomtien Conference, the concept of "Science for all" had already come into being in the light of the reflection carried out by researchers and educationalists (Bangkok, September 1985, Karachi 1986) ([1]).

The concepts at work would have to be redefined first to specify the objectives and strategies of such an education.

SCIENCE AND TECHNOLOGY FOR ALL: MEANING AND DEFINITION

The effort made to work out a widely agreed definition of the concept of Science for All at the Regional Workshop organized by UNESCO Education Innovation Programme for Development for Asia and the Pacific in Bangkok (1989)' alone has revealed the complexity of such a definition.

As regards "Science for All", the Workshop has, on the basis of a concentric and crosschecking approach, adopted a notion of science that is "relevant, appropriate and accessible to both girls and boys of different

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1 Science for All Supporting Teacher change Report of a Regional Workshop. Science Education Research Unit, University of Waikats. Hamilton New Zealand and UNESCO Principal Regional Office for Asia and The Pacific Bangkok, Thailand 1989 P.1.

abilities, interest, cultures and professional preferences" that is based on situations encountered by children daily in their local environment", and that "is built on their curiosity and their existing knowledge" ([2]).

One can already understand the necessity of relating Science Education, as regards children, to social and cultural differences and idiosyncracies, and differences in sex, and the rejection of an education which would aim mainly at training future specialists. The option for Science is perceived as part of the basic knowledge of mankind nowadays, and even more so in the future.

But the relevance of a conceptual approach to Science and Technology, working out and implementing an effective strategy in the field of the individual's Education and training, can only be achieved through a consistent effort to identify approaches reflecting the given idiosyncracies.

Thus, if Science is viewed as "the entire knowledge of laws governing natural phenomena" ([3]), it should include formal, empirico-formal and hermeunetic ones for which the notion of operation seems to represent a general criterion as regards their status, a notion which is found in both purely formal approaches and experimental ones ([4]).

Technology known as "the study of techniques" carried out with the purpose of spreading knowledge and developing technical reflection ([5]) may be used to discover new laws of nature and, therefore is a medium for the development of science but it cannot be simplified to science.

The aim of Education and Teaching being the acquisition of knowledge by the individual, a first series of questions is raised therefore about :

- the knowledge, skills and behaviours which correspond to Science and Technology;
- the relevance of the latter to a given social group.

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2 Ibid P. 7.

3 Science Jean Ladrière)
Encyclopedia Universalis vol. 20 p. 725

4 Ibid P. 725

5. Endogenous Technology, a synopsis for its inclusion into Science Education in African schools.
Magatte THIAM Advisory Committee Session.

The answers depend on the purposes and the objectives assigned to that education as well as on their development and inter-relations.

The 1992 world report on human Development, published by the United Nations Development Programme (UNDP), after having shown the poor results of several decades of efforts aiming at reducing slightly the gap between the economic development of the most deprived countries and that of the affluent minority, mentions again that human development has to be the real aim to pursue througthout the world.

"It has mentioned that "the concept", based on the development of human abilities and their effective use, opens up economic opportunities for all and makes everyone participate in the development process". ([6])

Therefore, Science and Technology Education has to make it possible for every member of our societies to contribute to and fully participate in the life of the community by improving all aspects of that life.

Various objectives of science and technology education arise from this, among which are :

- The training of specialists (executives, technicians, researchers, teachers),
- and raising the cultural standard of the whole population.

In fact, the above mentioned UNDP report shows a table of social development ratings for all the states. The average school attendance in 1990 is between 10.4 and 11.6 for developed countries and between 0.2 and 3.7 for African countries.

It shows even more clearly the significance of development difficulties due to obstacles reflected in the low level of science and technology applications because of the shortage of qualified personnel and the slow spreading of science education in African societies among other factors.

Providing continuing education is one of the main procedure to address the issue in addition to working out strategies at the same time to improve the effectiveness of the education system, especially in the field of science and technology in formal education.

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6. Unequal results for unequal partners. Robert Rowe.
The Courier - Africa - Caribbean - pacific - European Community
N° 134/July - August 1992.

In Africa of course the tasks of mobilizing all productive forces and linking education with development have resulted in many important programmes in the informal field; functional literacy, continuing education and programmes intended for the advancement of women.

Science and Technology education should therefore be adapted to identified local needs, so that the social groups concerned can use it to solve the daily problems encountered in their environment.

It must be added that the difficulties involved in learning science and technology have led one to think of approaches to education adaptable to the local environment in order to use all resources of indigenous technologies. New lines of discussions attempt to find elements relating to Science in the cultural legacy specific to Third world countries.

The concepts of ethnomathematics and ethnosciences put foward by Urbinatan d'Ambressio ([7]) and Paulus Gerdes ([8]) take into account the cognitive knowledge acquired by a child or an individual from his/her original environment.

Finally, the development of closer and closer links between Science and Technology justifies the review of the concept of Science and Technology Education which can no longer suffer from compartmentalization but needs further integration, especially with regard to programmes. The "Technical and vocational training" Information Bulletin, by underscoring the impact of new technologies especially in developed countries at an International Congress held in Berlin in 1987, indicates that vocational education and training,..., tend to be the link between the formal and informal education system and the workers([9]).

It is a fact that science and technology education should not aim at elitist training only but at the same time it should:

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7 The history of Mathematics and Ethnomathematics. Taking native cultures into account in learning sciences.
Urbinatan d'Ambrassio. Impact Sciences n° 160 - UNESCO

8 On culture, Geometrical thining and mathematics education.
Paulus Gerbes Educational Studies in Mathematics (1988)
137 - 162.

9. Technical and Vocational Training n° 9 - 1988 - UNESCO

- Link, in the most relevant way, knowledge acquisition following specific criteria, to the environment, provide the whole society with extensive knowledge ;
- and make it possible to produce specialists of all desired standards including highly trained ones.

The fact stated above leads to considering science and technology education with several components and dimensions.

Fundamental education in the formal field aims at training the individual with a view to diversifying specializations, starting from an effective level of integration in active life and of adaptability to the development of science and technology.

Within the framework of a comprehensive raising of knowledge standard, informal education aims at mobilizing traditional and endogenous technologies, at acquiring new scientific approaches and methodologies, at informing people in order to control the development of modern environment.

Continuing education regards mainly adapting to a changing context, creating the conditions for the development of a technological innovation.

The objectives of extra - school education are to:

- Broaden learners' information and field of activity ;
- stimulate their sense of creativity and their innovation potential ;
- broaden their contact with the environment ;
- encourage education based on methodology as well as the ability to work in groups.

The approaches to education contents and methodologies have to be harmonized and converge on a comprehensive process.

CONTENT OF SCIENCE AND TECHNOLOGY EDUCATION FOR ALL

Determining in concrete terms the content of science and technology education for all is a complex problem with a double interrogation.

The first one is of didactic and educational nature. It consists of defining a curriculum which can be mainly used for educating the majority of children while avoiding "dropping" out. The main characteristic of such a curriculum would be to provide all children with fundamental education, education being regarded as a process and fundamental education as a minimum requirement.

The second one is the correlation of contents with "dropping out", which could lead to designing a minimum curriculum adapted to the critical level at which the students drop out for the first time.

Which knowledge acquisitions would be regarded as basic ones? Which education methodologies would be appropriate to such contents ? How to take into account the development of scientific and technological knowledge?

An international working group set up by the International Committee on Mathematics Education has carried out a study on "School Mathematics in the 1990s" which has amply addressed this issue in the specific area of mathematics by underscoring the context of developing countries. The working group lays emphasis on the difficulties which would arise from the various concepts aiming at devising a curriculum taking dropping out into consideration.

In the light of the numerous work and surveys carried out in developed countries and according to information contained in Third World Countries curricula, the content of Mathematics education for children (aged 5 to 14) includes:

- understanding arithmetic calculations and being aware of when and where practical calculations should be used ;
- numeration;
- developing the skills in using mental arithmetic first to provide right answers to simple problems and, subsequently to provide approximate answers to more complex problems ;
- evaluation and approximation ;
- developing skills, finding the solution to problems by using testing methods regarding approximation ;
- data analysis at an elementary level ;
- elementary probability theory and statistics ;
- scientific numeration and notation ;
- relationship between numbers and geometry ;
- fractional numbers, comparision, decimal representation ;
- calculating geometric magnitudes with two and three dimensions, ordinary formulae ;
- elementary set concepts and concepts related to appropriate sets regarded as tools and objectives ;

- function concepts in keeping with dynamic growth and decline models ;
- algebraic symbolism and techniques especially during the last two years ([10]).

The ability to use calculators or computers in a selective way to develop concepts or make complex calculations is another aspect.

This raises the problem of the local context which differs from one country to another and is still reflected in the curricula of secondary schools where realities are very varied, even among developed countries. Thus, in the United States, one can choose not to do mathematics any more, whereas in France, that is not possible.

In Africa, one can note already that in markets and shops traders use calculators. Thus, although experiments and initiatives aiming at using computers in primary and intermediate education are starting gradually, the tool is becoming widespread, following its own dynamics.

Similar information contained in other subjects and in some fields which, like environment, appears as aspects that are necessary to an individual's fundamental education and have practical links with science, would make it possible to work out the basic elements of a curriculum to be used in science and technology education for all.

The question is which methodological approach to use :

- Science education being regarded as a process, how can one avoid the traditional approach favouring contents or being reduced to a presentation technique ;
- What kinds of situations and problems greatly help the student develop his/her skill in solving problems ?
- How to really link science with technology?

There are many experiences in this field based on thematic and spiral-like approaches.

Determining clearly the concept as the curriculum basis as well as defining and implementing steps arising from the need to improve curricula and education methodologies appear to be the main problems:

- Reviewing the contents of science and technology teachers' training programmes ;

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10 School mathematics in the 1990s
ICMI Study Services
A.G. Howson and J.P. Kahane Editors - Cambridge University Press

- Relevant teaching aids development, especially by promoting their development through local means.

The advisory Committe 5th session has indicated that the issue of "science for all" had to be interpreted as "quality science for all but in keeping with the needs". ([11])

The improvements to be made in contents and therefore in teachers' training and the introduction of new curricula are not easy as can be seen from experience.

In preparing the human resources development programme (PDRH) in Senegal, an evaluation mission has indicated that:

It is true that in rural areas, especially motivated teachers will be needed to integrate practical work in theoretical education in order to obtain a unified education scheme so that pupils leaving primary school can take care of themselves and become agents who will improve the area.

In urban areas, on the other hand, the kind of practical work to be included in theoretical education is yet to be devised. But school inspectorates responsible for teachers' training are not prepared to design this kind of programme ([12])

Besides working out basic teaching aids, there is the serious problem of training not only teachers but the entire staff involved in educational management. The role to be played by various categories of personnel in the change process should be made clear.

Moreover, the difficulties in implementing changes raise other issues regarding change processes on which the discussions of the 7th Congress of the International Committee on Mathematics Education (ICME) focused:

- How important are the means of implementing curriculum change ?
- What available information is there about what really happens in the classrooms or schools in terms of results of the practical attempts to bring changes ?
- Is it necessary to have an improved assessment with feedback ; how could it be achieved ?

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11 Advisory Committee meeting on Science and Technology Education Reform in Africa, fifth Session - Regional Office for Education in Africa BREDA - 3 -7 December 1990. Final Report/P. 104

12 Human Resources Development Programme (P.D.R.H.) Education/Training Department - Mission carried out from 1 to 30 april 1991. Ministry of National Education Memorandum.

- What seems to be the main impediments to change and, which books could be used to improve the system ?
- What kinds of pressure or support could be more effective?
- What role could teachers play in the curriculum change process ?
- What could be the contribution of research to the success of curriculum change ?
- How could one check whether a new approach is working properly.([13])

These questions provide a framework for working out strategies to introduce programmes such as "Science and Technology for all", which is something new. But the framework of questions should be extended in order to encompass extra-school Education and formal and informal continuing education.

SUGGESTED STRATEGIES FOR IMPLEMENTING A SCIENCE AND TECHNOLOGY EDUCATION PROGRAMME FOR ALL IN AFRICA

It has to be specified from the outset that even if the concept "Science and Technology Education for all" is a concept which concerns all societies, the variety of education systems with more or less centralized characteristics, with so different levels of organization and development, will be reflected in the strategy approach, especially in terms of aids which will back up the programmes. One can nevertheless pinpoint some essentiel elements of strategy which should be necessary:

- Working out a curriculum based on the concept of science and technology education for all

Defining and adopting such a curriculum are a first step in the strategy. This should itself be designed as a process and therefore involve specialists in educational sciences, in management, in educational planning, in vocational training and in social development.

The complex nature of the task requires a thorough consideration of teaching problems related to sciences and technology, of trends in development and professions, in the light of new technologies, of problems, of human settlements and of culture etc...

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13 Methods of implementing curriculum change.
ICME 7 ; Working group 18. Background paper February 92.

The approach adopted in this step is of paramount importance; if it means getting field teachers involved in office work, the objectives may well not be achieved. Therefore, this first step has to be based on broad consultations.

There are various institutions in different countries which can carry out this activity : curriculum development centre, Permanent National Committees on Reform, Educational Science Research Centre. For information only, it is necessary to go deeper into the experience of National Meetings on Education Research and Training.

- Teachers and technical staff' training and supervision

This second step is also fundamental and certainly the most difficult one for at this stage, the problem of means already arises considering the shortage of science and technology teachers.

In this regard, the main question is that of the motivation for and the support to teachers involved in the change process with a view to helping them change their own concept of this education and start an innovation process at their own level :

This regards the way they perceive science, technology, society and the activity in the classroom and in the environment.

One concept reflecting a number of experiences would be the setting up of a generalized system of research/training groups, which can use one or several educational networks for curricula development, for working out and producing teaching aids and for research in the field of education.

That would make it possible to extend the field of improvements in the way teaching is organized or carried out.

Flexibility could make it possible to meet satisfactorily the specific characteristics in one or several establishments or structures and also fit current events.

Senior staff could be trained to supervise this kind of activity under the aegis of a training department located at a given administrative level.

- Setting up or improving a scientific and technological information system.

In this regard, one must take into account not only information centres devoted to findings in sciences and technology, but also the network of public reading at school and outside of schools, libraries, museums the aims of which should be defined

To this end, one can think about:

- An improved management of science and technology sectors in libraries and cultural centres in addition to real activities (organizing conferences, using new audio-visual aids);
- Encouraging the use of reading libraries in school establishments;
- Encouraging the publishing of school and extra-curricular books.

A series of surveys have been carried out in this field in Kenya and Senegal by the Committee on the promotion of science publications for children led by Professor Odhiamko and, very useful recommendations for the promotion of scientific and technological publications for children aged 3 to 14 and suggestions for possible further surveys are available ([14]).

- Setting up an assessment system which will require some time. The assessment must certainly be a comprehensive one but it should be extended to include teachers

This should then contribute to increasing the teacher's awareness of this mission and of himself and, therefore to his training.

In order to carry out this task, it will be necessary to :

- détermine or set up observation or analysis units ;
- identify and implement a significant and coherent set of indicators to be used as reliable instruments related to knowledge acquisition, to training and professions, etc...
- encourage self-assessment in education circles;

CONCLUSION

Important issues like strategy elements have not been tackled. There are at least two among them, namely :

- working out teaching aids ;
- educational research.

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14 Science Culture in Africa from the beginning what our children read.
Sarak W. Maranycky and Mary. H. Bugembe. CHISCI Kenya 1990.
CHISCI pilot project. Catalogue of science publications for children aged 3 to 14. Final Report Dakar 1992.

Problems related to these two fields are also being focused on with the aim of reforming and improving science and technology education. The Advisory Committee on Science and Technology Education Reform has carried out a number of studies and encouraged the organization of a number of workshops with a view to implementing the guidelines.

Seeking to popularize the concept of Science and Technology Education for all makes it necessary even further to support such initiatives in order to:

- update agreement on methodological approaches to setting up national systems for working out and preparing teaching aids ;
- strengthen institutions of research in the field of science and technology education (coordination, researchers training, scientific publications development etc...)
- strengthen exchange of experiences and the pooling of resources to achieve progress based on collective autonomy and endogenous moves.

The setting up in August 1992 of an African Network for Science and Technology Education is an important step to be strengthened through an effort aiming at rationalizing, harmonizing and encouraging all the existing national, regional and sub-regional initiatives.-

SECTION II.

SPECIFIC STUDIES AND EXPERIENCES

Chapter Six

SUPPLEMENTARY READERS ON BASIC SCIENCE AND TECHNOLOGY CONCEPTS IN NIGERIA

Peter *OKEBUKOLA* *

Through the ages, the book, perhaps more than any other medium has been the fountain head of knowledge for learners of all ages. As Carlyle (1992) noted, "After all manner of professors have done their best for us, the place we are to get knowledge is books. The true university is a collection of books".

Textbooks, reference books and supplementary readers are three categories of books that are deemed essential in curriculum implementation. The textbook is usually the recommended course text for day-to-day usage. The contents are broad and the core topics in the programme form the focus of treatment. The reference book is a recommended text especially for specialised topics. The supplementary reader on the other hand is intended to enrich knowledge obtained from textbooks, reference books and other sources. The supplementary reader has a characteristic flavour of simplicity of language and an appealing layout. Unlike most textbooks and reference books, supplementary readers typically assume "nil knowledge" of the subject matter from the reader. This is why people in school or out of school, can take advantage of the supplementary reader for updating their knowledge of people, events or things including basic science and technology.

The supplementary reader in basic science and technology is an important medium for implementing Project 2000+ in Nigeria. Project 2000+ aims, among other things at (a) identifying ways of promoting the development of scientific and technological literacy for all; (b) putting forward educational programmes (both formal and non-formal) in such a way as to empower all to satisfy their basic need and be productive in an increasingly technological society; and (c) support the evaluation of

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* Deputy Vice-Chancellor and Professor of Science Education, Lagos State University (LASU), Ojo - Lagos - Nigeria.

existing and projected programmes to ensure that scientific and technological literacy goals are being met.

At the Project Forum in Paris in July 1993, broad means of achieving scientific and technological literacy for all were defined (UNESCO, 1993). These are (a) out-of-school scientific and technological activities; (b) mass media; (c) institution of informal science and technology; and (c) community-based programmes. Since between 20 to 40 per cent of the children in Africa are outside the formal education system, non-formal and informal education have major roles to play in developing scientific and technological literacy for all in the region. This further highlights the important role of out-of-school scientific activities within which the medium of supplementary readers fills an important niche.

In this paper, an effort is made to report a study which aims at describing the status of the development of such readers in Nigeria with a view to identifying problems associated with the development, proferring possible solutions and making prescriptions for collaboration among African countries.

THE STUDY: PURPOSE, QUESTIONS, METHODS

The purpose of the study was to assess the level of development of supplementary readers on basic science and technology concepts and their application for use at the basic and post-basic level of formal education in English and local languages in Nigeria.

To guide the survey, the following *research questions* were formulated and addressed:

i. What basic science and technology extra-curricular reading materials are available for use in and out of school in Nigeria?
ii. How accessible are these basic science and technology supplementary readers with particular reference to (a) cost; (b) availability/actual purchase and use; and (c) language?
iii. What is the level of social and cultural relevance of the contents of the readers to the Nigerian child?
iv. How involved are indigenous authors in the development of supplementary readers on basic science and technology concepts?
v. How can the development of supplementary readers on basic science and technology concepts be promoted?

Data on the research questions were gathered from the following during *interview sessions*:

(a) Managing/Publishing Directors or Marketing Managers of four publishing houses reported to carry the most respectable number of titles on supplementary readers in science and technology in Nigeria. These were:
   - Longman Nigeria Plc
   - MacMillan Nigeria Publishers Ltd
   - Evans Nigeria Plc
   - Heinemann Educational Books Nigeria Plc.

(b) Bookshop manager (or representative) of
   - Abiola Bookshop
   - Lagos State University Bookshop
   - University of Lagos Bookshop
   - Ahmadu Bello University Bookshop.

(c) Executive Secretary of the Nigerian Educational Research and Development Council (NERDC).

Questionnaire developed on the research questions was responded to by headteachers of twenty randomly selected primary schools, fifteen randomly selected secondary school science teachers and seventeen people who can be classified as part of the general public who are out of school.

QUESTION 1

What basic science and technology extra-curricular reading materials are available for use in and out of school in Nigeria?

The supplementary readers' market in Nigeria was adjudged by all the publishers surveyed to be very rich. These readers appear largely in series such as the Heinemann Windmill Series, New Windmill Series and the MacMillan Hop-Step-and-Jump Series. Relative to others however, the supplementary readers on basic science and technology concepts and their applications were found to be rather few. Figure 1 shows the proportion of supplementary readers in science carried by the sampled publishing houses and bookshops relative to science and general supplementary textual materials

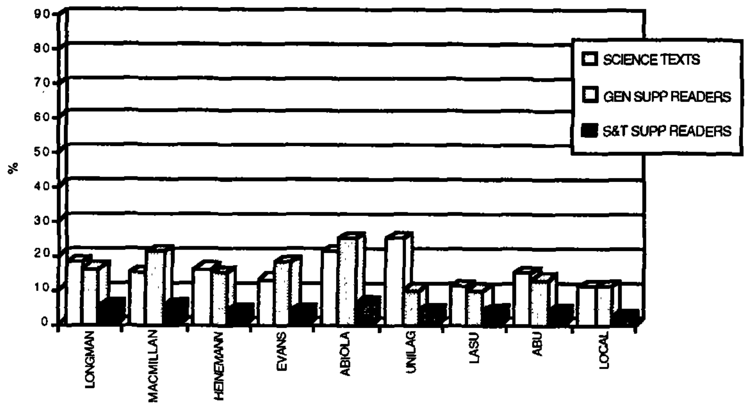

Fig.1: Percentage of Stock by Type of Text and Publisher/Bookshop

None of the publishing houses has more than 3% of the titles in its 1993/94 stocklist and catalogue as supplementary readers in basic science and technology.

The availability of the titles in bookshops was also assessed. Apart from Abiola Bookshop with 4% of the books carried under supplementary readers focusing on basic science and technology, all the other bookshops have two per cent or less of their books in this category. The "local" bookshops in the Lagos metropolis have less than one per cent.

The major titles carried by the publishers/booksellers are shown in Table 1.

Table 1

Supplementary Readers in Basic Science and Technology by Publisher

AUTHOR	TITLE	PUBLISHER
Carter	World of Science: Air	MacMillan
Carter	World of Science: Energy	MacMillan
Carter	World of Science: Heat	MacMillan
Carter	World of Science: Light	MacMillan
Carter	World of Science: Rocks and Minerals	MacMillan
Carter	World of Science: The Solar System	MacMillan
Carter	World of Science: Water	MacMillan

Carter	World of Science: Weather and Climate	MacMillan
Thomas	The Environment	MacMillan
Thomas	Pollution	MacMillan
Thomas	The Green House Effect and the Ozone Layer	MacMillan
Howes	A Place for Them All: Animal Homes	MacMillan
Pidgon	Earthworms	MacMillan
Thomas	Air Transport	MacMillan
Thomas	Television	MacMillan
Thomas	My Teeth	MacMillan
Thomas	Growing Things	MacMillan
Thomas	Dangerous Animals	MacMillan
Thomas	Light and Colour	MacMillan
Thomas and Stutchbury	Snails and Lizards	MacMillan
Bailey	Snakes and their Young	MacMillan
Butterworth	Ants and their Nest	MacMillan
Butterworth	Unusual Fish	MacMillan
Howes	Animal Jigsaw	MacMillan
Macintosh	Exploring Space	MacMillan
MacMillan	WWF Environmental Impact 2000	MacMillan
Thomas and Stutchbury	Ants	MacMillan
Thomas and Stutchbury	Endangered Animals	MacMillan
Ngumy	The Boy who ate the Hyena	MacMillan
Brain Read	The Water We Use	Heinemann
Sinom Seymour	Discovering What Earthworms Do	Heinemann
John Kaufmann	Birds in Flight	Heinemann
M.E. Selsam	Animals As Parents	Heinemann
David A. Hardy	The Solar System	Heinemann
Zim Science Series	Armoured Animals	Heinemann
Zim Science Series	Blood	Heinemann
Zim Science Series	Waves	Heinemann
Heinz Kurth Books	Time	Heinemann
Heinz Kurth Books	Engines	Heinemann

Heinz Kurth Books	Oil	Heinemann
Jonathan Rutland	Fastest Things	Evans
Theodore Rowland	The Restless Earth	Evans
Veronica Lynn	Microbes and man	Evans
John May	The Balance of Nature	Evans
Sue Nash	All About Dogs	Evans
	Learn About Nature	Longman
	The Motor Car	Longman
	The Computer	Longman
	Flight	Longman
	West African Butterflies and Moths	Longman
	West African Insects	Longman
	Large Mammals of West Africa	Longman

What factors account for the scarcity of supplementary readers in science and technology in the Nigerian market was a subsidiary question of interest. In interview sessions, the following explanations were given:

> *There is a lack of science and technology awareness in Nigeria hence the scant attention paid to the development of supplementary readers in basic science and technology. Besides, many primary school teachers who should have encouraged pupils to read such texts have poor training in science.*
>
> Dan Obidiegwu
> Marketing Manager, Longman Nigeria Plc

> *Publishers are not investing in the development of supplementary readers in basic science and technology because of low returns on investment. Most of the readers are imported and hence by current exchange rates, cost a fortune. Since we are not in position to recoup our investment fast enough, we do not feel encouraged to carry many of the titles in that category.*
>
> Dr. Adenekan
> Managing Director, MacMillan Nigeria Publishers Ltd.

We are contented with the main texts. We do not place as much premium on supplementary readers in basic science and technology since teachers do not bother asking their students to read texts outside of the main textbooks in science and technology. One is not inclined to invest the scarce foreign exchange available to our company on importing the supplementary readers in basic science and technology which hardly sell.

Ayo Ojeniyi
Director (Publishing) Heinemann Educational Books (Nig) Plc.

The market is slim for the supplementary readers in basic science and technology because of the examination orientation of our educational system. People only care for texts that will give them a short cut to passing examinations. The bottom line for the publishers and booksellers is the MARKET. Since the market is not encouraging, only a handful of publishers and booksellers will venture into such a business.

Sunday Oyalami Country Representative of Kluwer Publishers of Holland Lagos, Nigeria

QUESTION 2

How accessible are these supplementary readers in basic science and technology with respect to (a) cost, (b) availability and actual purchase and use; and (c) language?

Table 2 provides data on the cost of the supplementary readers in basic science and technology.

Table 2

Cost of Supplementary Readers on Basic Science and Technology

PUBLISHER	MINIMUM COST IN US$	MAXIMUM COST IN US$	AVERAGE COST IN US$
LONGMAN	3.00	8.00	3.00
MACMILLAN	2.70	8.00	3.50

HEINEMANN	2.56	9.42	3.50
EVANS	1.78	10.38	3.80

On the average, the supplementary readers have retail value of about three US dollars. This would appear to be good pricing considering that almost all the texts are imported. However, when viewed from the context of the minimum wage of US$180 per month and Nigeria's rating as one of the world's thirteen poorest nations, such cost for a supplementary reader is unattractive.

On availability for purchase, the study showed that all the publishing houses and bookshops have a few copies of the readers. Indication was given of the capacity to order large quantities at short notice if the market becomes attractive.

When presented with the list of titles, teachers and pupils and the out-of-school persons surveyed, gave information as summarised in Table 3.

Table 3

Assessment of Accessibility for Purchase and Use of Supplementary Readers in Science and Technology by Teachers, Pupils and Out-of-School Others

Author	Title	Publisher	% seen and read text before		
			Teachers	Pupils	Others
Carter	World of Science: Air	MacMillan	0	0	0.5
Carter	World of Science: Energy	MacMillan	0	0	1.0
Carter	World of Science: Heat	MacMillan	0	0	1.0
Carter	World of Science: Light	MacMillan	0	0	1.0
Carter	World of Science: Rocks and Minerals	MacMillan	0	0	1.0
Carter	World of Science: The Solar System	MacMillan	0	0	0
Carter	World of Science: Water	MacMillan	1.0	0	1.0
Carter	World of Science: Weather and Climate	MacMillan	0	0	0
Thomas	The Environment	MacMillan	0	0	0.5
Thomas	Pollution	MacMillan	0	0	0
Thomas	The Green House Effect and the Ozone Layer	MacMillan	0	0	0
Howes	A Place for Them All: Animal Homes	MacMillan	0	0	0

Pidgon	Earthworms	MacMillan	0	0	0
Thomas	Air Transport	MacMillan	0	0	0
Thomas	Television	MacMillan	0	0	0
Thomas	My Teeth	MacMillan	1.0	0.5	2.0
Thomas	Growing Things	MacMillan	0	0	0
Thomas	Dangerous Animals	MacMillan	0	0	0
Thomas	Light and Colour	MacMillan	0	0	0
Thomas and Stutchbury	Snails and Lizards	MacMillan	0	0	0
Bailey	Snakes and their Young	MacMillan	0	0	0
Butterworth	Ants and their Nest	MacMillan	0	0	0
Butterworth	Unusual Fish	MacMillan	0	0	0
Howes	Animal Jigsaw	MacMillan	0	0	0
Macintosh	Exploring Space	MacMillan	0	0	0
Mac Millan	WWF Environmental Impact 2000	MacMillan	0	0	0
Thomas and Stutchbury	Ants	MacMillan	1.0	1.5	2.0
Thomas and Stutchbury	Endangered Animals	MacMillan	0	0	0
Ngumy	The Boy who ate the Hyena	MacMillan	0	0	0
Brain Read	The Water We Use	Heinemann	0	0	0
Sinom Seymour	Discovering What Earthworms Do	Heinemann	0	0	0
John Kaufmann	Birds in Flight	Heinemann	0	0	0
M.E. Selsam	Animals As Parents	Heinemann	0	0	0
David A. Hardy	The Solar System	Heinemann	0	0	0
Zim Science Series	Armoured Animals	Heinemann	0	0	0
Zim Science Series	Blood	Heinemann	0	0	0
Zim Science Series	Waves	Heinemann	0	0	0
Heinz Kurth Books	Time	Heinemann	0	0	0
Heinz Kurth Books	Engines	Heinemann	0	0	0
Heinz Kurth Books	Oil	Heinemann	0	0	0
Jonathan Rutland	Fastest Things	Evans	0	0	0
Theodore Rowland	The Resteess Earth	Evans	0	0	0
Veronica Lynn	Microbes and man	Evans	0	0	0
John May	The Balance of Nature	Evans	0	0	0
Sue Nash	All About Dogs	Evans	0	0	0
	Learn About Nature	Longman	0	0	0

	The Motor Car	Longman	2.1	0.0	1.5
	The Computer	Longman	2.0	1.0	3.0
	Flight	Longman	0	0	0
	West African Butterflies and Moths	Longman	3.0	1.65	10.0
	West African Insects	Longman	10.0	5.0	10.0
	Large Mammals of West Africa	Longman	5.5	2.0	12.0

Table 3 shows clearly that the supplementary readers in science and technology are hardly noticed and read by teachers, pupils and people outside the schooling community.

When asked whether or not they had read supplementary readers in basic science and technology outside the list given, only a few of the sample gave indication of having read any of such material in the last four years. The claim was made that:

> *I prefer to read comics and magazines rather than a supplementary reader in science.*
>
> Pupil of LASU Staff School

> *I do not know what a supplementary reader in science and technology is.*
>
> Teacher in a public primary school in Ibadan

On the issue of *language*, none of the readers is written in the local language; all are in English. Since English is the country's official language, a fair portion of the target group of users of the supplementary readers could be expected to be able to read such texts.

QUESTION 3

What is the level of social and cultural relevance of the contents of the readers to the Nigerian child?

The supplementary readers reviewed are all authored by non-Nigerians, each bringing his or her social and cultural background to bear on the contents of the text. Consequently, apart from the scientific message being passed on to the reader, relevance to the Nigerian socio-cultural setting is low. For instance issues relating to malaria, sickle cell, guinea worm, sewage disposal, erosion, food preservation, vessico-viginal fistula(VVF) are more relevant at this time than supplementary readers on rockets, global warming and ozone layer depletion (see Table 1).

QUESTION 4

How involved are indigenous authors in the development of supplementary readers on basic science and technology concepts?

As can be seen in Table 1, none of the authors of the supplementary readers on basic science and technology concepts is a Nigerian. Of the 52, only one is an African. This is not to say that a few indigenous authors are not making efforts to write. The publishers are not encouraged by the nature of the market to support the publication of such texts. As declared by one of the publishers:

> *I have an excellent manuscript - a supplementary reader on science and technology that has been favourably reviewed. We are keeping its publication on hold until we have funds that can be tied down for a fairly long time since the market for that category of text in Nigeria for now, is unattractive.*
>
> Ayo Ojeniyi
> Director (Publishing), Heinemann

A promising series was being developed at the time of the survery by Professor Sam Bajah. As President of Science Teachers Association of Nigeria (STAN) in the mid-80s, Professor Bajah attempted getting the Association to develop such titles that could help to promote basic scientific and technological literacy. The proposal on this effort is being finalised by STAN. Of the new Bajah series, an assessment is:

> *I am impressed with Professor Bajah's efforts. NERDC is planning to publish and promote the series.*
>
> Professor U.M.O. Ivowi
> Executive Secretary
> Nigerian Educational Research and Development Council
> (NERDC)

QUESTION 5

How can the development of the supplementary readers on basic science and technology be promoted in Nigeria?

This question was posed to publishers, booksellers and some science educators. There was consensual agreement that if the market is rich, many more authors and publishers would venture into the enterprise. The summaries of the views expressed are:

> *I propose three strategies. First, the populace needs to be made aware of science and technology through other media e.g. radio and television. As the awareness deepens, greater interest will be generated in reading the supplementary readers. Another strategy is for agencies like UNESCO to support the development of such texts through provision of seed funds and to guarantee a sizeable percentage of the market. A third strategy is a re-orentation away from examination consciousness especially at the primary school level where the focus is on Mathematics, English and General Knowledge. If science is one of the compulsory subjects, perhaps greater interest will be shown for the supplementary readers.*

Dan Obidiegwu
Marketing Manager, Longman

> *Teachers should be encouraged to recommend supplementary readers to students.*

Ayo Ojeniyi
Director(Publishing) Heinemann

The need for *regional cooperation* in the development of the texts was emphasised especially in such areas as:

* sub-regional author collaboration
* development of texts in national languages
* development of texts that would address superstitious beliefs in Africa
* development of texts in story form
* development of texts with comical and graphical orientations.

CONCLUSION

This study has, attempted to provide answers to five questions related to the development of supplementary readers in basic science and technology in Nigeria. Though the study lacks full national coverage; it however reached out to those areas where the bulk of potential readers reside. It is hoped that the efforts of UNESCO BREDA towards achieving the objectives of Project 2000+ in the Africa region through the development of supplementary readers on basic science and technology concepts through the POP-SCI-TECH-AFRIC project would take cognisance of some of the findings of the study.

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Chapter Seven

SCIENCE AND TECHNOLOGY CLINICS FOR GIRLS IN GHANA

J. *ANNAMUAH-MENSAH**

Ghana like other African countries, recognizes the key role science and technology could play in its socio-economic and political development. Numerous recommendations adopted by African countries have reaffirmed this. For example, in the Lagos Plan of Action (OAU, 1981) African governments were urged to encourage the learning of science and technology at the basic level of education and also use science to spearhead the transformation of developing states into developed states. This issue was emphasized at the Harare Conference of Ministers of Education (Conference of Ministers, 1982) and the Pan-African Conference on Education (1984). At the 47th Organization of African Unity Ministerial Conference in 1987, the pivotal role of science and technology in Africa's progress was given such a recognition that it was agreed that 30th June of every year should be declared the "Scientific Renaissance Day". These initiatives conform with the spirit of the World Declaration Of Education For All that suggested that "close contact with contemporary technological and scientific knowledge should be possible at every level of education" (World conference on Education for all, 1990).

Ghana has responded to this by introducing science in the Primary, Junior Secondary (JSS) and Senior Secondary (SSS) as a subject taken by all students while technology is taken as a vocational technical subject at the JSS and SSS levels. The objective of this intensification in the creation of a science and technology base was to lift Ghana out of its poverty, insanitary conditions, diseases, ignorance, superstition, tedious agricultural practices, poor housing, environmental degradation, deforestation and desertification.

However a decade after the initial adoption of a science and technology strategy for development, Ghana with a population of 15.4 million and growth rate of 3 is faced with an adult literacy rate of 60.3%

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and life expectancy of 55 years. Also, 5.9 million people do not have access to health services while 6.5 million and 10.3 million do not have access to safe water supply and proper sanitation respectively (UNDP, 1992).

Although there is a dearth of up-to-date statistics on science and technology personnel in Ghana, estimates indicate that as at 1982 there was a stock of 1,800 engineers and 8,100 technicians in the country. This by all standards is low. Ghana needs about 12,000 engineers and 48,100 technicians by the year 2000 for scientific and technological development to take off (Mohamedbhai, 1993).

The importance of a science and technology culture makes it imperative that the entire human resource potential of the country should be tapped for economic and social development. In Ghana, the feminine citizenship which constitute fifty-one percent of the population has remained untapped. This group constitutes a rich resource that needs to be developed for the socio-economic transformation of the country.

Available statistics on the participation of females in education in general indicate that female participation decreases as one climbs the educational ladder. Table 1, for example shows that in the primary schools the ratio of girls to boys is nearly 1:1. However, there is on the average a sharp drop from Primary to J.S.S (ratio of boys and girls is 1:0.7) and even a sharper drop (70.9%)

Table 1: Enrollment of Boys and girls in Primary, JSS, and SSS Education from 1989 - 1990

Level	1988		1989		1990	
	Boys	Girls	Boys	Girls	Boys	Girls
Primary	887,261	711,182	939,010	764,064	939,010	811,271
JSS	357,244 (59,7%)	251,446 (64,6%)	366,830 (60,9%)	258,188 (66,2%)	337,108 (66,0%)	232,235 (71,4%)
SSS	103,991 (70,9%)	50,486 (80,0%)	112,542 (69,3%)	55,458 (78,5%)	133,58 (60,0%)	65,679 (71,7%)

Source: Adapted from Ministry of Education Statistics, 1994 * Figures in parenthesis represent drop in enrollment.

From J.S.S. to S.S.S (ratio of boys and girls is 1:0.5) giving a pyramidal structure to enrollment in education. The drop-out rate is greater on the average for the girls (72%) than for the boys (645%). For example, there is a 59.7% and 70.9% drop in the boys enrollment from

Primary to J.S.S. to S.S.S. respectively. Similarly, there is a drop in girls' enrollment of 64% and 80% from Primary to JSS and JSS to SSS respectively.

Policy to boost female participation in Science

Although there is no deliberate policy to debar girls from pursuing science and technology many educators have become concerned about the very low representation of girls in science and technology subjects. To ensure that the disadvantaged situation of girls in science and technology is addressed, a number of policies have been put in place by the Ministry of Education. These are:

Science is taken by all pupils at the Primary and Junior Secondary School levels. Girls and boys are therefore given equal opportunities to participate fully in Science and Technology activities at these levels.

At the secondary level, the policy of the Ministry of Education for the old system of Education which is phasing out is that all students should offer at least one Science subject for the GCE Ordinary Level Examinations of the West African Examinations Council after five years of study. With the new educational reforms, Core Science which is more of an interdisciplinary nature than integrated has been made compulsory for every Senior Secondary School student.

At the Universities, various regulations such as admitting females with slightly lower GCE A-Level entry grades than boys has helped in bringing more females into courses such as Pharmacy, Science, Biochemistry and Agriculture.

There is also the policy that the Universities should work towards achieving an enrollment ratio of boys to girls of 60:40

The Ministry of Education has since 1990 insisted that both boys and girls in the Junior Secondary School should study traditionally male subjects such as Woodwork, Carpentry and Masonry and female subjects such as dressmaking.

Girls In Science And Technology Education

A number of facts can be observed about the participation of girls in science and technology in the secondary and tertiary school system in Ghana. Table 2 and 3 show that in general fewer girls choose science subjects as examination subjects at the Ordinary level and the Advanced level of the General Certificate of Education of the West African Examination Council. Girls enrollment in chemistry physics and additional mathematics is far lower than in biology and additional general science. However, over the period 1981-1991. there is a slight increase in female enrollment in the sciences. At the sixth form level fewer girls choose chemistry and physics than biology (Table 3). There has been on the average an increase in the enrollment of girls in the sciences at the sixth form although the increase has not been steady over the years.

Table 2

Choice of Science and Mathematics Subjects as Examination Subjects, 1981-1991

	Chemistry		Biology		Physics		AddMath's		Add Gen Science	
Year	M	F	M	F	M	F	M	F	M	F
1981	2790	310	3360	705	2535	292	2654	308	146	76
1982	2839	379	3504	777	2931	374	2608	324	158	64
1983	2614	285	3183	710	2608	275	2000	293	141	73
1984	2911	295	3427	659	2855	287	2801	379	124	62
1985	2525	272	2958	743	2634	265	2538	364	45	78
1986	2520	320	2874	838	2491	316	2591	383	65	57
1987	2856	380	3328	1087	2895	373	2889	466	57	50
1988	2747	460	3323	1288	2781	438	2727	427	21	3
1989	3005	557	3306	1300	3096	551	2934	564	5	1
1990	2839	578	3459	1415	2923	556	2095	582	8	2
1991	2960	587	3273	1556	3002	599	3213	656	2	2

Adapted from Ministry of Education Statistics, 1994

Although it is a well known fact that fewer girls choose science and mathematics subjects in the secondary schools, Table 4 shows that the percentage of girls Passing GCE 0-Level chemistry and physics is comparable or better than the percentage of boys passing these subjects.

Table 3

Number of Students Writing GCE 'A' Level Examinations in Science: 1981 - 1991

	Chemistry		Biology		Physics	
Year	M	F	M	F	M	F
1981	1146	109	611	106	1137	113
1982	1249	120	498	96	1180	115
1983	1054	95	402	81	1130	99
1984	1152	119	386	89	1113	117
1985	1127	134	472	104	1136	129
1986	1469	142	551	t06	1487	141
1987	1216	152	688	132	1258	155
1988	1311	174	710	144	1307	173
1989	1257	162	548	115	1318	161
1990	1161	188	432	129	1167	192
1991	1028	171	348	99	1164	172

Adapted from Ministry of Education Statistics, 1994

Table 4

Percentage of Passes in the GCE 'O' Level by Subject and Gender 1981 - 91

	Chemistry		Biology		Physics		Add Math's		Add Gen. Sci.	
Year	M	F	M	F	M	F	M	F	M	F
1981	56	49	27	18	54	52	44	31	53	61
1982	52	48	25	14	51	42	43	37	42	84
1983	34	38	35	22	44	47	58	56	49	75
1984	52	51	37	27	60	64	54	40	67	76
1985	49	53	33	25	53	55	23	11	60	67
1986	70	70	48	26	49	46	48	54	46	77
1987	54	53	36	20	52	48	56	54	53	60
1988	49	62	23	18	59	65	44	51	57	100
1989	51	57	21	15	41	45	48	50	100	100
1990	44	54	26	20	45	46	38	41	100	100
1991	33	41	33	20	48	51	36	37	100	100

Source: Adapted from Ministry of Education Statistics, 1994

On the average a greater percentage of girls pass additional general science than boys. Boys seem to have a better edge over girls in biology while there is not much difference in performance in additional mathematics. This suggests that if more girls are encouraged to take the science subjects they may perform as well as boys.

The situation is almost the same in the GCE A-Level examinations (Table 5) At the A-Level, a greater percentage of girls seem to pass chemistry and biology than boys Percentage performance in physics can be said to be comparable.

Table 5

Percentage of Passes in GCE 'A' Level by subject and Gender 1981-91

	Chemistry		Biology		Physics	
Year	M	F	M	F	M	F
1981	58	6	52	10	65	5
1982	68	7	52	12	58	6
1983	55	6	50	12	76	7
1984	48	6	16	5	56	7
1985	46	5	59	12	62	6
1986	56	6	59	12	66	6
1987	59	8	68	14	50	5
1988	39	5	65	13	43	5
1989	45	7	70	16	40	6
1990	45	9	62	19	42	7
1991	58	10	68	18	59	12

Source: Adapted from Ministry of Education Statistics, 1994

Thus even at this high level there is some indication that given the chance to multiply their numbers, girls may even outperform boys

At the University level, enrollment of girls in degree programmes in science and technology is very low Using the University of Cape Coast as an example, the data in Table 6 shows that about five times more boys get enrolled in undergraduate courses in science than girls. There is however an observed increased in the enrollment from 1991/92 to 1993/94.

Table 6

Enrollment of Students in Science Courses at the University of Cape Coast by Programme and Gender, 1991-92/1993-94

	Undergraduate		Postgraduate		Diploma	
	M	F	M	F	M	F
1991/92	515	86	-	-	37	7
1992/93	496	90	16	1	45	8
1993/94	641	138	33	1	52	10

Source: University of Cape Coast: basic Statistics, 1994

The situation is more serious at the postgraduate level where female enrollment is negligible. The diploma programme for laboratory technicians which is of 3 years duration enrolls only a skeletal number of females.

A close look at of the enrollment of females in vocational technical institutes in the country (as represented in Table 6 shows a marked under representation of females over the years. The situation is slightly better in the polytechnics although it is still appreciably low.

Table 7

Percentage Enrollment of Females in Vocational Technical institutions

Year	Technical/ Vocational Institutes - Full Time	Technical/ Vocational Institute - Part-Time	Polytechnic Full-Time	Polytechnic Part-Time
1981/82	8.9	10.3	19.6	18.7
1982/83	9.0	7.8	23.0	31.8
1983/84	8.1	12.5	18.7	36.0
1984/85	8.5	12.9	19.2	30.2
1985/86	8.3	8.4	21.3	27.8
1986/87	7.5	9.0	21.8	25.5
1987/88	7.9	9.4	25.3	25.3

1988/89	9.2	5.4	22.3	21.7
1989/90	9.6	7.0	22.2	32.5
1990/91	10.3	6.0	23.2	32.4
1991/92	10.5	8.2	26.2	34.8

Source: Ministry of Education: Tertiary Level Statistical Digest, 1994.

It is interesting that the educational system makes some attempts to provide equal opportunities for all students to participate in science. Ghana's educational system is at the present in a state of flux. The old educational system with its sixth form structure is gradually giving way to the new system - the 6-3-3-4 system. This stands for a six year primary education, 3 year junior secondary education, 3 year senior secondary education and 4 year tertiary/university education. The educational system in Ghana is structured in such a way that some introduction to science is provided at the primary level. At the junior secondary school level science is part of a common core of subjects and it is aimed at giving students a basic grounding in the principles of science. Girls and boys are thus given equal opportunity to participate fully in science activities at these levels.

It is at the secondary school level that there is some degree of streaming that allows students to specialize in Science, Technology, visual arts and Agriculture. The aim is to inculcate an interest in solving practical and technical problems as well as develop a better understanding of the principles of science and its applications. This is where there is a differential choice of science and technology-based subjects by boys and girls. However, the 'core' science which constitutes one of nine common core subjects in the senior secondary system, is intended among others to enable students to relate science to their everyday life. This 'core' science therefore provides the opportunity for both boys and girls in the senior secondary schools to participate in science. But when it comes to choosing science and technology as an optional subject girls tend to shy away from them.

BARRIERS TO FEMALE PARTICIPATION IN SCIENCE AND TECHNOLOGY

Various reasons have been given to explain why for generations females have been discouraged from being scientifically and technologically literate.

The Ghanaian society is impregnated with norms and values that dictate the roles and activities of the two sexes. These norms and values with deep roots in the culture affect the psychological make up of both sexes.

There is the general traditional view that women are fragile and should not be made to perform strenous activities. there is also the view that the women's place is in the kitchen and in the care of children; they therefore do not have to be breadwinners and hence aspire to become scientists. These views dictate the kind of activities that boys and girls can engage in. For example, the toys that are intentionally (or unintentionally) given to girls and boys when they are young, and the tasks they are expected to perform (Harding, 1994) heightens the roles they are to play when they become adults. While boys are given car toys, girls get dolls and playhouse.

It has been said that as a result of the activities they engage in and the role mapped out for them by society, girls tend to be relationship-oriented or person-oriented while boys tend to be career-oriented or object-oriented (Jaarsma, 1987). What this means is that girls will tend to choose subjects which will lead them to non-science and technology careers. Where science and technology subjects are chosen, these may be in the area of, for example, Home Science and Nursing.

Another source of problem is the expectations of science and technology teachers. Many teachers express surprise when` girls perform well in their Science, Mathematics and Technology classes. There is also evidence that some science and technology teachers unintentionally become oblivious of the females in their classes.

Other factors such as religious practices have also been seen as contributing to the marginalization of females in Science and Technology.

What Next ?

These problems are faced by many other nations in Africa. The World Declaration on Education for All states in Article 3 that "*The most urgent priority is to ensure access to, and improve the quality of, education for girls and women and to remove every obstacle that hampers their active participation. All other stereotyping in education should be eliminated*" (World Conference on Education for All, 1990, p.5)

Recognizing the need to evolve strategies to redress the gender imbalance in Science and Technology education, the Ghana Education

Service (GES) hosted a conference co.-sponsored by the commonwealth secretariat in Ghana in January, 1987 on the theme "Gender Stereotyping in Science, Technology and Mathematics Education". Recommendations from this conference led to the institution of the Science, Technology and Mathematics Education (STME) Clinic for girls as an activity of the GES in August, 1987 (Ghana Education Service, 1987, 1988, 1989).

Since then, the Science and Technology Clinic for girls has been carried out every year. It is aimed essentially at removing the stereotyped attitude of girls to science and technology subjects in the schools and thereby increase the participation of women in science and technology occupations.

WHAT IS SCIENCE AND TECHNOLOGY EDUCATION CLINIC?

The Science, Technology and Mathematics Education (STME) Clinic is essentially an activity aimed at encouraging "human resource development, institutional capacity building, networking, training and experimentation in educational methodology" so as to narrow the gender gap in science and technology. It is a part of a concerted effort to create a culture of science and technology in Ghana.

The activity was called a clinic in analogy to a hospital situation where a problem condition is diagnosed for its causes and a prescription made to remedy the condition or solve the problem. The problem under consideration in science and technology education is the low participation of women in science and technology. The diagnosis for the causes of the 'malaise' is derived from research work carried out on girls in Ghana by the STME Unit of the Ghana Education Service (GES) and also from studies in other countries. Some amount of diagnosis is also carried out on the girls attending the Clinic through a pretest which is given prior to the commencement of the activities of the programme. The pre-test is a way of unearthing the level of understanding of the problem (and attitude) of girls in science and technology, and the misconceptions they hold.

The prescriptions for correcting the imbalance constitute the activities which the girls are taken through during the programme. Thus, it can be surmised that the STME Clinic *is an activity aimed at prescribing a course of action or corrective measures to address the problem of low enrollment of girls in science and technology education* *after an initial diagnosis of the problem*. The measures taken involve the exposure of the girls to a variety of science and technology related activities and situations .

OBJECTIVES OF THE CLINIC

The science and technology education clinic for girls in Ghana is a new concept in the popularization of science and technology in the commonwealth. In the Asian workshop on Technological Change and Women Towards 21 st Century, organized by the Commonwealth Secretariat in New Delhi, India in 1990, the Ghana STME Clinic was adopted as one of the effective strategies to encourage girls into science and technology education (Ghana Education Service 1991).

The general objectives of the STME Clinic have been stated as follows:

a) To make participants aware of the gender stereotypes that tend to inhibit girls/women from entering STME based occupations and how women can overcome these inhibitions;
b) To encourage the girls to study the full range of science and mathematics related subjects in secondary schools;
c) To make participants aware of the application of science and mathematics skills in various occupations and in the production of goods and services;
d) To provide opportunities for participants to explore science and mathematics based careers through first hand experiences;
e) To reassure participants through role models that women can succeed in STM-based occupations and the same time maintain normal marital relationships;
f) To create opportunities for participants to improve their skills in observation and scientific problem-solving (Ghana Education Service, 1992, 1993).

The specific objectives of the clinic has been stated as follows: At the end of the STME Clinic participants will:

a) (Individually) show a decreased propensity to accept gender stereotypes that inhibit girls/women from entering STM based occupations;

b) (as group) show an increase in the number and range of science and mathematics subjects they have chosen tentatively for study towards future careers;
c) (as group), show increased interest in STM-based careers;
d) be able to identify at least four models of successful women in STM-based occupations;
e) be able to specify subjects that must be studied as preparation for entry into given STM-based occupations.

TARGET GROUP

Female science students in secondary schools from SSS 1 to Upper Sixth Form are selected by their Heads of Institutions using a well defined criteria from the Ghana Education Service. An average of 150 girls are invited each year. The criteria included the selection of two of the best science students in the school. In addition, terminal examination reports on the selected candidates were to be submitted to the GES Headquarters. Those who have participated in the clinic before are not allowed to participate again. This ensures that many more girls benefit from the workshop.

Over the period of seven (7) years about a thousand secondary school girls have had the benefit of participating in the science and technology clinic. With the passing of years, the clinic began to take on an international character. Table 8 shows that since 1989, some African countries Nigeria, Sierra Leone, Gambia, Namibia, Zambia and La Cote d'Ivoire have sent their secondary school girls to participate in the Clinic.

The clinic has over the years invited women scientists and technologists as role models. Around twenty role models come from Ghana while one or two come from other African countries. Apart from the role models a few female science and technology teachers in the secondary schools are brought to the clinic to assist the girls in their activities. Other people are invited to participate in the clinic as resource persons. These resource persons may be either men or women scientists and technologists. They are invited to give talks, engage the girls in hands-on activities and assist them with their project work.

Table 8

Number Of Girls Participating In The Clinic By Years And Country Of Origin*

COUNTRY OF ORIGIN											
Year	Ghana	Nigeria	Sierra Leone	Zam bia	Gambia	Namibia	Tanzania	Kenya	Bots wana	Togo	Cote d'Ivoire
1987	104 (10)										
1988	68 (6)										
1989	118 (25)	5 (3)	(1)	-	-	-	(2)	(1)	(1)	-	-
1990		-	4	-	-	-	-	-	-	-	-
1991	183 (25)	4	2	2	2	4 (1)					
1992	172 (22)	4	4	-	4(1)		4			(2)	(1)
1993	121 (25)	-	4 (1)	-	5	4 (1)					

* Numbers in parentheses indicate the role models participating in the clinics.

The science and technology clinic is organized with funds mainly from UNESCO, Commonwealth Secretariat and the Ghana Education Service. Support is also obtained from state, parastatal private institutions and industries either in kind or cash. Most of the funds go into accommodation and feeding and remuneration for resource persons.

The Clinic is organized as a residential activity during the long vacation period for secondary schools which extends from July to September. The duration of the workshop is two weeks and is usually organized from late August to September. In 1993, one-day Clinics were organized at the Regional level for primary and Junior Secondary Schools in some regions in the country.

CONTENT AND ACTIVITIES OF THE STME CLINIC

The content of the science and technology clinic for girls are planned in such a way as to expose the girls to content areas that are not normally covered in the formal school system. The organization of the content was such that an effective blend of the traditional subject-oriented content and the process and applications of the concepts in the various science and technology disciplines was achieved. It is noteworthy that the clinic is organized at a time when private vacation classes are also organized to provide remedial and tap-up teaching for secondary school students in the various science disciplines. Students invited to the clinic, especially those in the examination years (Form 5, SSS 3 & Upper 6) come to the clinic with the expectation that topics in the syllabuses will be taught just as it is done in the vacation classes.

Themes have been chosen each year to reflect scientific, mathematical and technological issues which have implications for the participation of females in the society and to guide the scientific content and activities for each year's clinic. Thus, since 1987 the following themes have directed the orientation of the clinics:

a) 1987 Women in Science
b) 1988 Careers in the pure and applied sciences
c) 1989 Women's role in the world of science and technology
d) 1990 Women's role in the world of science and technology
e) 1991 Science, technology and girls in nation building
f) 1992 Girls into science: Asset to the environment
g) 1993 Girls, science and sustainable environment.

The content of the clinic covers the processes involved in the production of goods and services (in industries), nature and use of computers, knowledge of women in industry, science and technology occupations and knowledge of the scientific method.

The content of the talks given at the clinics cover a wide range of issues from topical social issues such as AIDS, family life education and environment through descriptions of the work of science and technology professionals and to problem solving and applications in the science and mathematics disciplines.

The clinic was planned to provide the girls with the opportunity to experience science and technology in a variety of situations so as to extend the girls' science and technology experiences beyond those normally provided in their schools. To achieve this, a number of activities have been employed during the Clinic.

Table 9

Percentage of the Total Time Spent on the major activities during the Science Technology Clinic over the years*

Year WIST	MAJOR ACTIVITIES						
	Visit	Talk	Project Work	Film show	Group Discussion	Quiz	Meeting
1987	32 (19.0)	23.5 (14.0)	-	6.5 (3.9)	-	2 (1.2)	
1988	17 (10.1)	8.5 (5.1)	- -	12 (7.1)	-	3.5 (2.1)	
1989	51.5 (30.7)	25 (14.9)	-	18.0 (10.7)	1 (0.6)	2 (1.2)	
1990							
1991	58 (34.5)	8.5 (5.1)	20.5 (12.2)	5.5 (3.3)			
1992	61.5 (36.6)	5 3.0)	11.5 (6.8)	3 {1.83	3 (1.8)	-	2 (1.2)
1993	50 (29.8)	10 (6.0)	19** (11.7)	4.5 (2.7)	7.5 (4.5)	-	1 (0.6)

*The total time spent for the 14 days of the clinic was 168 hours calculated from 7.30 a.m .to 7.30 p.m. each day.

** Project work was developed through attachment to specific role models in science and technology.

Table 9 shows the major activities carried out in the seven Clinics conducted so far. In general, the educational visits take a greater proportion of the total time spent during the Clinic. For example, in 1993, educational visits alone took 29.8 percent of total time. The total Clinic time was calculated as follows: the 12 hours spent each day of the Clinic (from 7.30 a.m. to 7.30 p.m.) for 14 full days gives a total of 168 hours for the duration of the Clinic period. The time spent on each activity was then calculated by dividing the time (in hours) allocated to that activity by 168 hours.

ACTIVITIES

One of the major activities concerned in the clinics was the *educational visits*. These visits were made to industries, research institutions/laboratories, University science and technology departments, hydro-electric power generation plants, computer firms, medical school, integrated farm, national zoo, botanical garden, Air-Force base and Civil

Aviation, Broadcasting Corporation and Geological trip to rocky beach, among others. The visits provided the opportunity for the girls to experience science in action and to relate school science to everyday applications of science as seen in industry, on the beach, in the zoo and in the botanical garden. In most of the places visited, the girls were introduced to the administrative structure of the place as well as type of work done there. The girls were allowed to touch and feel and to engage in hands-on activities.

Talk or lectures also played a significant role in the clinic as seen in the table. The talks were given mainly by female role models who were practicing scientists and technologists. Topics included, the 'role of female technician in a medical laboratory.' 'Food processing and preservation in Ghana', 'AIDS', 'The role of nuclear physics in national development'. Other important topics were 'Sustainable environment', 'The maritime environment', 'Science in our daily life', 'You can enjoy mathematics', 'Plants for beauty', 'Physics: Queen of all sciences', 'Family life education', 'Immunology' and the 'Scientific culture'. It seems from evaluation of the clinics that talks which were supported by video materials had greater impact on the girls.

It is noteworthy that *the use of quiz* as a strategy for increasing the interest of the girls was not continued after 1989. Quizzes provided the opportunity for the girls to review their science and mathematics content knowledge.

Project work was introduced as a strategy for encouraging the development of scientific attitudes, experimentation, observation and report writing and the cultivation of the girls' interest in science. This was started in 1991. The projects of the girls are usually conceived by them during the interactions that occur in the clinic. For example in their visit to industries, farms and laboratories and during the talks by role models the girls usually pick up some ideas which may blossom into a well conceived project. During the 1993 clinic, the girls were attached in groups of two to four to some laboratories, industries and other science and technology oriented establishments of their own choice. The girls spent four mornings working under the supervision of mainly female scientists, industrialists and technologists who served also as role models. This attachment was used by many of the girls to develop their projects. This was an innovation in the clinic which was perceived by the participants as very beneficial.

In the development of the project, the girls worked closely with the role models who acted as supervisors. This created a welcome interpersonal relationship between the girls and the role models. Some of the projects worked on by the girls included: 'Construction of a burglar alarm system', 'Activities with flowers' and 'Bacteriological examination of water.'

Another novel activity introduced in 1992 was *the meeting of Women in Science and Technology* (WIST) with the participating girls. WIST is an association of women scientists, mathematicians, technologists, teachers and medical practitioners. "The purpose of the meeting was for the women to serve as role models to the girls and to make them gain some insight into the various opportunities existing in science and technology thereby assisting them to develop an early interest for science-related careers" (GES, 1993). However, only one evening is devoted to this.

The use of video and film shows is one of the activities that was used in the first clinic in 1987. This activity has continued to be used since them. The films used in the clinic ranged from those which related to topics in the chemistry, biology and physics syllabuses (e.g. cell biology, circulatory system, energy, electricity and magnetism) to those on topical issues (e.g.. films on 'Science and Environment', 'Plight of AIDS victims', 'Righting the imbalance' 'Life on earth', 'How to get better grades and have more fun', 'Girls in Science'). It is noteworthy that the video/films which made much impact on the girls were those that had some briefing before and discussions after the screening of the video/film.

Group discussion is also seen as an important strategy.

This group discussion is different from discussion which ensue from talks or lectures. In the group discussions, the facilitators, i.e. resource persons and role models, met with the girls most of the evenings to review the day's activities. It created a forum for the girls to share their experiences. It enabled the girls to process the experience they have been exposed to throughout the day. However, this activity was usually not successfully completed because of the poor participation of the girls who arrive from educational visits feeling tired.

Other activities include *role modeling*, career guidance and hands-on-activities. Role modeling is one of the first activities used in the clinic. It presented women who have succeeded in science and technology careers that the girls could emulate. Apart from women scientists and technologists invited to give talks, a number of other highly placed women in the field of science and technology were invited to serve as role models in the Clinic. They discussed how they rose to their present academic and professional positions. They also talked about their marriage life and how they have been able to cope.

Career guidance. One of the objectives of the Clinic is to encourage the girls to choose relevant science subjects that would enable them to enter into science and technology careers. Apart from role models who gave guidance in the selection of science subjects needed for particular science and technology professions, a professional guidance and counseling coordinator gave career talks to the girls. The talk attempted to motivate the girls and urged them to disabuse their minds of erroneous notions about science and girls participation in science (e.g. science is a male subject and is also difficult).

Hands-on activities. Another characteristics of the clinic is the provision of hands-on activities for the girls. This seems to have been used in the last two Clinics held in the country, that is 1992 and 1993. The hands-on activities chosen for the particular Clinics related to the theme for the Clinic. For example, in the 1993 Clinic, activities related to environmental issues were selected to correspond to the theme: "Girls, science and sustainable environment". The activities were drawn from physics, biology, chemistry or mathematics. Some of the activities were: Construction of bridges, air pollution, use of insecticide cans to test Newton's law of gravity, chemical games and demonstrating processes in physics with simple materials.

HUMAN, MATERIAL AND FINANCIAL RESOURCES

A successful science and technology Clinic requires the input of both human, material and financial resources. The human resources consist of the women role models who are invited to give talks, act as facilitators and provide career guidance. These role models are carefully selected females who have excelled in the field or science and technology and are at the same time successful in their marriage lives. The Clinic has had occasions to use role models from other African countries. Other people participate in the clinic as resource persons and organizers. The organizers see to the smooth running of the clinic. They see to the logistics, transports visits, and day to day management of the clinic. Some other resource persons (mainly males) are invited specially to give talks in specialized areas.

The material resources for the conduct of science and technology Clinics are made up of physical structures, that is fixed infrastructural facilities and 'moveable' materials which need to be brought to the site. These may change with the theme of the Clinic. The infrastructural facilities include adequate accommodation and feeding facilities to cater for the participants. Meeting places and laboratories are also required for group activities. Also needed for the clinic are adequate transportation to convey the participants on their educational visits. Some of the vehicles used for the educational visits are provided by some secondary schools. In order to show educational video films in the evenings or during lectures, the Clinic has its own video monitor, and video deck. A video camera is used to assist in capturing some of the events occurring during the clinic. A still camera is also needed to take snapshot of events during the Clinic. Other materials may be required for some of the activities during the Clinic but these depend on what the resource persons and role models need for their specific activities with the girls as well as what is needed for the projects. Some of these requirements may be poster papers, writing materials, wood and dry cells. Finally, the clinic cannot be organized without adequate financial inputs. Feeding at the clinic, fuel for transportation, honoraria for resource persons and role models and purchase of project materials require some money. As mentioned earlier some support for the clinic comes from UNESCO and the Ghana Education Service but quite a reasonable amount also comes through the contributions of the industries, non governmental organizations and individuals.

EFFECT OF THE CLINICS ON GIRLS

The Science and Technology clinic for girls is intended to help breakdown the psychological barriers that obstruct girls from studying science and technology subjects in the schools. Activities are therefore planned to disabuse the minds of the girls about the myths surrounding female participation(or non-participation) in science and technology. Evaluation of the clinics shows that activities such as role modeling, visits and talks seen to make a great impact on the girls.

The girls in the clinics have at the end of the clinic always expanded their knowledge of career opportunities open to girls beyond medical officers (doctors) and pharmacists to include radiologists, medical laboratory technicians, microbiologists, electronics engineer, biochemist, mechanical engineer, etc.

The girls come to the clinic with misconceived ideas about their role in science and technology education and future careers. These include:

i. Women scientists and mathematicians are not as feminine as other women.
ii. Girls who take science and mathematics have very slim chances of progress.
iii. If a woman becomes a scientist or engineer marriage will become a problem.
iv. Even if a woman studies science and mathematics she will finally end up in the kitchen.
v. Engineering is not a profession for females.
vi. Only gifted females can do sciẹnce and mathematics.
vii. Science and Mathematics are difficult subjects.
viii. You can't do other things when you are studying science.

These attitudinal stance with which the girls come into the clinic seem to reduce drastically by the end of the first two weeks clinics. The exposure to the role models, visits to industries to see the application of science and technology in industry and career options open to females, visit to university science departments for a better understanding of the school science subjects and other activities of the clinic appear to have a positive effect on the girls. For example, the career aspirations of the girls become modified; the girls come to understand that married female scientists can still practice their profession and that women can perform as well as men (Ghana Education Service, 1987). Some of the specific statements made by the girls are as follows:

"It (clinic) has encouraged me to do science"

"It exposed me to future careers in science and technology".

POSSIBLE FUTURE TRENDS

The Science and Technology Education Clinic in Ghana has not been able to enroll more than 200 girls each year. This is not satisfactory as many more girls are not able to participate in the clinic. To overcome this constraint, the clinic has been extended to the regional and district levels and to the Junior Secondary School level. Regional activities have been organized for JSS students taking into consideration the needs identified within the locality as well as the resources available in the locality.

The main purpose of reaching the girls at a younger age is to disabuse the minds of these young girls about negative attitudes on the role of girls in science and technology education . This is in a bid to catch them young before they become too comfortable holding these naive ideas.

STRATEGIES TO DEVELOP SCIENCE AND TECHNOLOGY CLINICS FOR GIRLS IN AFRICAN COUNTRIES

The experience gained by Ghana in the organisation of clinics should be made available to other African countries since the problem of the marginalisation of women in science and technology is worldwide but particularly serious in Africa. It has been noted earlier that at least seven countries in Africa have participated in the Ghanaian clinics by sending their students while eight African countries have sent role models in the science and technology field. It is possible that through their participation, these countries would have the necessary experience to mount their own form of clinics. However, apart from Botswana where the Ghanaian clinic influenced the setting up of the Roadshow (Ministry of Education, 1991), nothing realistic has happened in the other countries. The question probably is, what strategies need to be adopted or designed so as to enable other African countries start their own clinics?

The following itemized suggestions are being made to encourage the development of clinics in other countries:

(i) The Science and Technology Education Clinic should be housed in a unit or secretariat of its own. This unit should be a necessary part of the Science and Technology Education Directorate of the Ministry of Education or its implementation body. As is the case in Ghana, the unit may be more effective if it is placed under the Director-General of the implementing body. If there is no implementing body, then it should be supervised by the Director of Science and Technology Education Division.

(ii) The unit or Secretariat should have a full time national coordinator.

(iii) The National Secretariat should be computerized and should perform the following functions:

a. Keep data on women and girls in science and technology education careers.
b. Develop awareness by the creation of materials such as stickers, posters and booklets with positive messages about science and technology,
c. Make public awareness campaigns through the electronic and print media.
d. Conduct research into the attitude of students (girls) towards the study of science and technology related subjects.
e. Encourage research into the effectiveness of implementation strategies developed by the secretariat.
f. Train clinic organizers for the regions and districts.
g. Train teachers to use creative teaching strategies to make the teaching of science and technology more enjoyable, interesting and effective in attracting more girls into science.

(iv) A Science and Technology Board made up of representatives from University Science and Technology Departments, Industries, nongovernmental organizations (NGOs), Ministry of Education and Ministry of Environment, Science and Technology should be set up. This could be a sub committee of the National Task Force of Project 2000+

(v) The Ministry of Education should have a line in its budget for the clinic .

(vii) Funds for the clinic should also be solicited from Industries, Private Companies, NGOs and individuals. The popularisation of Science and Technology is high on the agenda of UNESCO; as such financial support can be sought from UNESCO. Specific project documents should be developed and used to solicit funding from NGOs such as USAID and Overseas Development Agency (ODA) of Britain.

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Chapter Eight

SCIENCE AND TECHNOLOGY CLINICS FOR GIRLS IN BOTSWANA

Topoyame *D. MOGOTSI**

Science and technology clinics are activity oriented workshops where girls/women are made aware of their capabilities in Science and Technology (S & T). During these gathering, girls'/women's abilities are evoked through participation or involvement in various practical activities, talking and listening to role models at work or just watching videos showing different activities that other women get involved in.

These clinics therefore, primarilly aim at sensitizing people (in this context -girls) about Science and Technology.

William. P., said this during the S &T Roadshow held in Botswana (1990):

> Science and Technology hold some of the Key to Development and to unlocking Africa's resources so as to improve living standards on the continent. It is vitally important that girls and women share the same access to opportunities in science as their brothers and husbands, and that they themselves embark on scientific and technological careers, since they represent half a nation's talent and recognising the special role they play in relation to their children's upbringing and values even more of its potential (page 1).

Thus, S & T clinics seek to show girls/women that they could succeed in many more aspects of employment if they sought the relevant qualifications and training in S & T.

After the initial aim, then, the clinic should intend to popularise the idea and see to it that girls are encouraged to freely attempt the S & T careers.

* Ministry of Education, Gaborone - Botswana.

Therefore, clinics need to be designed in such a way as could bring about change on attitudes and myths which prevent girls from taking advantage of the 21st century opportunities in S &T.

THE BOTSWANA ROADSHOW

In Botswana, the idea of girls clinics came about following an initiative by COMSEC. African countries were invited to be hosts for the S & T Roadshow (intended to move from one place to the other) for girls. Botswana through the Ministry of Education, seized the opportunity of being the first host with the hope of harnissing existing efforts. Thus, the first Commonwealth Secretariat Science and Technology Roadshow for Girls' was held in Botswana in August 1990.

Before this, the only activities which took place in the country were Mathematics and Science fairs. Design and Technology exhibitions and Agricultural fairs. These however did not and still do not pay any particular attention to the issue of gender. It was only during the preparation for the Roadshow that the serious disparity existing between boys and girls in S & T, was realised.

Through statistics, it was realised that very few girls do enter courses which lead to Scientific and Technical careers and that access to educational institutions is not enough as there are other influencial factors such as, parents' way of raising their children ; advice and encouragement from teachers and employers etc. Hence, the Roadshow an international venture, was the first clinic for girls in Botswana intended to address the issue.

Botswana like other countries, portrays the model which is dominant S & T where S & T is practised by men. It has been upholding male values and devaluing/ignoring women's S & T capabilities. Therefore, for these countries, where there is an acute shortage of "wo" manpower in careers of Science and Technology, the answer might lie in involving girls.

Therefore, the Roadshow aimed at :

i. making girls/women aware that they too can choose S & T related careers.
ii. alleviating the myths and attitudes (either held by themselves or others) which withold girls/women from taking advantage of the opportunities accorded them in S & T.

The objectives included the following:

i. To enable girls to apppreciate the avenues for employment in Science and Technology if appropriately trained.
ii. To encourage society to develop positive attitudes towards girls and women in Science and Technolgy thus creating equal access in career development.
iii. To expose our country to a key strategy for enhancing the participation of girls in Science and Technology.
iv. To find and develop ways of widening the interest of learners especially girls in Science and Technology.
v. To create awareness of the need for national commitment to encourage girls/women to participate in Science and Technology courses as well as enhance existing programmes which aim at encouraging girls to appreciate that Science and Technology contribute a lot to the quality of life.

TARGET GROUP, ORGANISATION AND ACTIVITIES

Eventhough the initial idea was to invite only girls, in consideration of the 2nd aim, it was decided to include boys as participants in the ratio 2:1 (girls to boys). Only those with better aptitude in Maths, Agriculture, Science, Design and Technology, as well as winners from exhibitions (about 50 Students per venue). Twenty-four teachers per venue were invited in order to expose them to the idea of clinics and to pave way for replication in their respective regions/schools. The SADC countries were invited to send 2 girls and a teacher each for participation. Resources people and Role Models were brought from within in the country and outside particular from Nigeria, Ghana, Kenya, Uganda, and Zambia.

The roadshow started with three organisers but the number multiplied manifold (to about 50) due to the amount of work involved in the preparation. The Ministry of Education, other ministries, non governmental organisations, embassies etc, willingly offered their contributions both professionally and financially to the venture (about 40 Contributors).

The committee was broken down into smaller ones to prepare for different aspects of the roadshow such as documentation, programme,publicity, transport and accomodation, career guidance etc.

Every now and then, these committees came together for the purposes of coordination. The roadshow moved from Gaborone to Francistown and one was the repeat of the other except for some activities like competitions.

Following the main objective of the Roadshow as :

"to allow girls to "discover" themselves as scientists, to take away any fears they might have of science and technology, and show them the way leading to such careers" (Report p.9). It mainly consisted of practical activities - using workshop tools (designing say, a pendant and then making it); exposure to computers; assembling equipment (e.g bicycle); scientific and technical games and puzzles. Career Guidance clinics involved - a number of careers grouped in areas with a coordinator and role models per career area group. Included were medical careers, engeering, etc.

Practical activities were intended to "break psychological barriers that students, especially girls, often have against Science, Maths, Design and Technology; ... that there is nothing very difficult or impossible about Science and Technology and that in fact, it can be quite fun". (Ibid p.12).

Each session was two hours long which was obviously not enough to teach them enough skills. In any case, the aim was not to develop any skills per se, but rather to stimulate the students and alleviate any fears that they might have in using the particular equipment.

Career guidance (a clinic within the Roadshow) proved very valuable in that a lot of questions were answered regarding training, sponsorship, career opportunities, etc. These were asked not only by students but the public as well.

Another activity that developed during the show, was the Roadshow Magazine. This was produced daily and it provided in-house publicity - giving some kind of report on the events of the previous day. Some interviews were conducted and there were even letters to the editor. It was written by some of the participating students in addition to the other activities.

Just like pratical activities, *role models* were used to nestivate students' curiosity, encourage and excite their interest to pursue learning scientific and technical subjects. These were women who have opted for and succeeded in Scientific and Technical fields. The Role Models from within the country and other African countries (as mentionned earlier), were used as speakers, panelists and so on. In addition a role model video for the Career Guidance Clinic was developed showing women at work.

The Roadshow has been quite a success in as far as conscientising all present of the problems existing about girls and Science and Technology. It created a lot of awareness not only to the target group (girls) but all those who took part in it, either through sponsorship or through participation in committees. Because of its vast publicity aspect, a lot of indirect follow ups have been made.

Eventhough it is still a bit early to evaluate the effects of the Roadshow in terms of its participants (whether they have taken up or will end up following careers in Science and Technology), some effects on other people are noticeable. For example, its effect on Policy makers, Government officials, private sectors, employers and so one, was felt immediately as well as being significant, for example:

i. The roadshow came up just before the production of the National Development Plan Seven (NDP 7) and inevitably made a lot of input in it.
ii. A Project, jointly coordinated by the Department of Water Affairs and the Ministry of Education to involve more girls into the water sector careers.
iii. Botswana decided to train more women in engineering than men, more than ever before.
iv. Career Guidance and Counselling Unit decided to produce Gender Biased materials (some Roadshow committee members initiated this venture).
v. A video was made showing all the activities of the Roadshow. In addition to its use in other different countries like the UK (Leeds University in particular), the national university uses it for training purposes, to encourage girls to stay on the Scientific and Technical subjects.

All in all, there was an unintended/unplanned outcome which was that all those who were involved in the Roadshow, either in preparation or participation or sponsorship, i.e. employers, teachers, donors etc, gained a lot of insight into the problems leading to the shortage of "wo" manpower in Science and Technology related fields.

FUTURE PROSPECTS, WITH SPECIAL REFERENCE TO ADOPTION BY OTHER AFRICAN COUNTRIES

The National Commission on Education 1994 mentions that aggressive plans should be made to popularise Science and Technology among students and to inculcate in them positive attitudes. It further recommends that, "special measures should be developed to increase the participation and performance of girls in Science, Mathematic and Technology" (p. 25).

Thus, Batswana are called upon to bring about activities which will lead to the follow up of the Roadshow at regional level.

The content as well as activities can be as laid down in the Roadshow Manual. However one needs to caution that activities should be chosen in accordance with the local needs/situations as well as the availability of resources both human and material.

Recommended strategies are:

* "Start little and develop big". That is, begin locally/nationally and try an international event once in a while. Contact big organisations for help financially, materially, professionally or otherwise.
* Conscientize people such as students, parents, teachers, employers and the community at large,. apart from doing so through their involvement in the clinics,
  - call parents to Parents Teachers Association (PTA) meetings to inform them and solicit their help and cooperation,
  - teachers through staff meetings of school based workshops or Teachers' Forum, etc...,
  - Community, through village gatherings (Kgotla meetings), media and others,
  - employers through media, etc.

Through these efforts, emphasize the country's needs, particularly regarding Science and Technology manpower and development.

* Set up Task Force (TF) which will works as the Steering Committee therefore taking care of the National clinics and later give birth to Regional Organising Committee (ROC).
  - with the help of the TF, the ROC will organise clinics for girls at regional level (e.g. in Botswana TF will be former members of the Roadshow).

Regionalising these clinics will help spread the idea to more girls out there. It is at this level, that a lot of parents could be involved especially in Career Guidance clinics, helping to remove the fears they hold about their daughters "doing" Science and Technology.

- Role Models could come from towns around the villages etc. These need to be given guidelines or be briefed before they deliver their bit.

Materials/Resources required :

* **Logo** - could start with this, to be used on all correspondence and publicity materials e.g. Posters, folders, bags etc.
* **Human** -Ministry of Education could act as the coordinating body through the use of its Science and Technology specialists. These could then co-opt more people from other ministries, to form a large organising committee which could later be broken down into smaller ones.

Role Models, depending on the situation, participants may need to visit these at their works place and where not possible, a video of these at work will do. However, there should be a lot of them during the clinics.

* **Posters** - these could be distributed nationally even prior to the clinics and can still be used during the event as displays .
* **Funds** - All of the above, show that a lot of paper and secretarial services are needed, **therefore, a lot of money.** It should be realised that money will also be needed for people's stay at the venue and many other things too. Fundraising committees should ask for money from both governmental and non governmental organisations in order to meet the need.

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